TAMPERE UNIVERSITY OF TECHNOLOGY

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VALIDATION OF A MOBILITY IMPACT ASSESSMENT METHOD

Master of Science Thesis

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ABSTRACT

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Mobility is willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people's and road users' attitudes, opinions and choices in their daily travelling and movement. The concept of mobility is hard to fully define, and has often been reduced to transport or confused with accessibility or efficiency.

This study was carried out as part of a Finnish large-scale field operational test under the TeleFOT project. In this study the correspondence of 63 Finnish test participants' travel data from travel diaries and user-activated data loggers were analysed. Travel diaries were fully answered on average in 96.3% of travel diary (TD) entries; 68.4% of travel diary trips were made as the driver of a car or van. Trip end time correspondence in data sets had the lowest percentages, as more TD markings could have been made by estimation. The two data gathering modes did not work well together, as only 55.9% of journeys were found from both data. Moreover, 18.0% of logged trips were fragmented, compromising the reliability of the logger data results.

Based on the results of this study, the average Nordic test participant tends to be quite scrupulous and meticulous when dealing with TD, but there was a divergence with the use of data loggers. The results of TD–logger data correspondence divided participants into three groups: "good", "mediocre" and "poor" corresponding to their performance on data matching of trip start time, trip end time, trip duration and length.

TIIVISTELMÄ

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Liikkuminen (eng. mobility) tarkoittaa ihmisten tahtoa liikkua potentiaalisen ja toteutuneen liikkumisen rajoissa. Termin sisältöä ei tulisi rajoittaa tarkoittamaan vain ajoneuvojen, ihmisten ja hyödykkeiden liikkumista. Liikkuminen koostuu ihmisten mielipiteistä ja asenteista eri liikkumismuotoja kohtaan ja liikkumistapojen välisestä valinnasta heidän päivittäisessä kulkemisessaan. Englannin kielessä liikkumisen sijaan usein käytetään termejä saavutettavuus ja tehokkuus, mutta nämä kattavat vain osan sen sisällöstä.

Tämä tutkimus on osa TeleFOT-projektin Suomessa tehtävää laajaan kenttäkokeeseen perustuvaa tutkimusta. Työssä pyrittiin validoimaan tutkimusmenetelmää, jossa tutkimushenkilöiltä kerättiin aineistoa matkapäiväkirjoilla ja automaattisilla tiedonkeruulaitteilla. Matkapäiväkirjojen täyttöaste oli keskimäärin 96,3 %, ja 68,4 % matkapäiväkirjaan merkityistä matkoista tehtiin henkilö- tai pakettiauton kuljettajana. Vain 55,9 % matkoista löydettiin molemmista aineistoista. Lisäksi 18,0 % tiedonkeruulaitteella kerätystä datasta oli sirpaloitunut useampaan osaan.

Tulosten perusteella suomalainen tutkimushenkilö on keskimäärin tunnollinen matkapäiväkirjan täyttäjä, mutta hänellä on ongelmia matkapäiväkirjan ja tiedonkeruulaitteen yhteiskäytössä. Kun testihenkilöt jaettiin kolmeen ryhmään molemmista datoista löytyvien matkojen määrän perusteella ja verrattiin näitä ryhmiä yhdistettyjen matkojen tuloksiin, huomattiin vain parhaan ryhmän henkilöiden saavuttavan parhaita tuloksia kun taas kaikki huonoimmassa ryhmässä saavuttivat vain huonoimpia tuloksia.

PREFACE

This Master of Science thesis was completed as part of the TeleFOT project at VTT Technical Research Centre of Finland.

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Hervanta, March 2011

Maija Hakonen

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ABBREVIATIONS AND NOTATIONS

bCall	Breakdown Call
Driveco	DRIVECO personal is a green driving advisor for smart phones and an automatic driving diary provided by EC-Tools Oy
DAS	Data Acquisition Systems
Data logger	Equipment used to collect data straight from a car, for example GPS data or data from an OBD-II interface
eCall	Emergency Call for car accident.
EPOMM	European Platform on Mobility Management
FOT	Field Operational Test
GD	Green Driving service, a function of TeleFOT
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
ICT	Information and Communication Technology
ISA	Intelligent Speed Adaptation
ITS	Intelligent Transport System
LATIS™	Logica's location ware traffic information solution for drivers
Logger data	Data gathered via data logger

OBD	On-Board Diagnostics is a generic term referring to a vehicle's self-diagnostic and reporting capability.
SA	Speed Alert service, a function of TeleFOT
SI	Speed Information service, a function of TeleFOT
TD	Travel Diary
TD data	Data gathered via travel diary
TeleFOT	TeleFOT is a large-scale collaborative project under the Seventh Framework Programme, co-funded by the European Commission DG Information Society and Media within the strategic objective “ICT for Cooperative Systems”.
TI	Traffic Information service, a function of TeleFOT
VMS	Variable Message Sign
QZSS	The Quasi-Zenith Satellite System is a proposed three-satellite regional time transfer system and enhancement for the Global Positioning System that would be receivable within Japan.

1. INTRODUCTION

1.1. Background

Mobility in itself has not often been studied in the context of intelligent transport systems (ITS), but is now taken as one area of TeleFOT impact assessment including safety, environment, mobility, efficiency, and user uptake. TeleFOT is a large-scale collaborative project studying aftermarket nomadic devices in field operational tests (FOTs). Officially started on June 1st 2008, the 4-year project aims to test the impacts of driver support functions on the driving task with large fleets of test drivers in real-life driving conditions. TeleFOT assesses via FOTs the impacts of functions provided by aftermarket and nomadic devices, including future interactive traffic services that will become part of driving environment systems within the next 5 years. (TeleFOT 2008.)

Up to 3,000 drivers in TeleFOT-equipped vehicles will be driving around in eight of the European Union (EU) member countries involved in the project: Finland, Sweden, Germany, the United Kingdom (UK), France, Greece, Italy and Spain. High-tech in-vehicle active safety and efficiency technologies represent a great opportunity to improve mobility. Such technologies, which for the most part are already in existence, have the ability to help drivers make driving safer, more comfortable and more efficient. Yet these technologies have not penetrated the market, largely due to a lack of understanding about the potential benefits to driving behaviour and hence to quality of life. (TeleFOT 2010.)

1.2. Purpose of the study

The purpose of this thesis was to elaborate on the concept of mobility in the context of ITS and how the mobility impacts of ITS can be studied. An additional purpose was to describe the method used in TeleFOT for mobility impact assessment and to validate it. Specifically, one purpose of this thesis was to validate the reliability of travel diary (TD) data and the data logged directly from the vehicle. However, it must be noted that in this study, no impacts on mobility could be studied. Nevertheless, the study gives a picture of how reliably data about present mobility can be collected. Consequently, it gives a basis for assessment of the reliability and validity of the mobility impacts studied later in the TeleFOT project.

The subject of the thesis is interesting, as the correspondence between TD data and logger data has not previously been studied much, and the study can bring some insight concerning reliability. Also, the concept of mobility is not established in the context of ITS. Consequently, the thesis offers a definition for use among ITS professionals. Little research has been done on the mobility impacts of ITS, although it is assumed that the demand for mobility impact assessment will increase in the future. This thesis has been prepared as part of VTT's contribution to the TeleFOT project.

The thesis starts with a theoretical and literary review in the second chapter. The third chapter presents TeleFOT and the research method used in the validation. The fourth chapter shows the validation results, and the discussion and conclusions follow in the final chapters.

2. THEORETICAL AND LITERARY REVIEW

2.1. Validity and reliability

Two concepts – reliability and validity – are discussed because they provide the benchmarks by which data analysis and collection are measured. In short, reliability refers to the probability that the repetition of the same procedures, either by the same researcher or by another investigator, will produce the same results. Validity refers to the accuracy of a given technique, that is, the extent to which the results conform to the characteristics of the phenomena in question. (Briggs, 1995.) One aim of this study is to validate the data-gathering methods used in the mobility impact assessment, in order to determine how the data sets correspond and how reliable a picture data logging gives about the test participants compared to TD data.

Reliability engineering is an engineering field that deals with the study of reliability: the ability of a system or component to perform its required functions under stated conditions for a specified period of time. It is often reported in terms of a probability. Reliability may be defined in several ways (Hayworth 2009):

- The idea that something is fit for purpose with respect to time.
- The capacity of a device or system to perform as designed.
- The resistance to failure of a device or system.
- The ability of a device or system to perform a required function under stated conditions for a specified period of time.
- The probability that a functional unit will perform its required function for a specified interval under stated conditions.
- The ability of something to "fail well" (fail without catastrophic consequences).

Reliability engineers rely heavily on statistics, probability theory, and reliability theory. The function of reliability engineering is to develop the reliability requirements for the product, establish an adequate reliability program, and perform appropriate analyses and tasks to ensure the product will meet its requirements. (Hayworth 2009.)

Reliability does not imply validity. That is, a reliable measure is measuring something consistently, but we might not be measuring what we want to measure. In terms of accuracy and precision, reliability is analogous to precision, while validity is analogous to accuracy. Verification and validation is the process of checking that a product, service, or system meets specifications and that it fulfils its intended purpose. (Hayworth 2009).

2.2. Concept of mobility

Traffic is a consequence of fulfilling people's needs to move. Moving in itself does not often benefit the person, but is a way to get to the place where the action that brings the benefit can be performed (Kalenoja et al. 2008). Mobility is the potential for movement. It consists of means of travel and networks one has access to and is willing to use (Kulmala and Rämä 2010; Spinney et al. 2009). The concept of mobility should be understood as being richer than just traffic and transport, as is often the case in existing "mobility" policies. Nor should it be reduced to mere accessibility or used as a synonym for efficiency. Mobility has a role in itself beyond, but not in opposition to, these two important concepts. (Gudmundsson 2005 in Thomsen, p.123)

When the basic transportation infrastructure and services are functioning well and people have a choice in their means of travel, the quality of travel often rises to be more important than the simple ability to get somewhere. Mobility in itself also includes people's preferences in travel and choices of time, mode and route, their feelings, and entails also the ease of travel itself. (Button et al. 2006; Gudmundsson 2005.) Mobility as a term is an umbrella containing traffic and transport with all the reasons and motivators, blending psychology and sociology into transport.

Mobility is a broad concept, and is largely used in many different contexts. According to Gudmundsson's (2005) "The Key Dimensions of Mobility", which he used to create a mobility policy that covered all aspects of mobility, mobility should be considered from four viewpoints:

- Mobility as potential and realized movement.
- Mobility as dependent on potency and tendency.
- Mobility as expressed in qualities and quantities.
- Mobility as externally and internally sustainable.

Mobility refers to the ease of movement rather than just movement itself, entailing also the potential to move. Actual movement is rather straightforward, easily conceivable in terms of distance and duration of the movement, whereas potential movement is the transport system's ability to enable a particular amount and type of movement to take place. Potential movement, which can also be understood as available systemic potential, varies in time and space and with the services used, as the peak rush hour blocks the streets but disappears as day turns to night. Actual and potential movements are not entirely separate but rather a nested set, actual movement being able to happen in line with potential (Figure 1). (Gudmundsson 2005.)

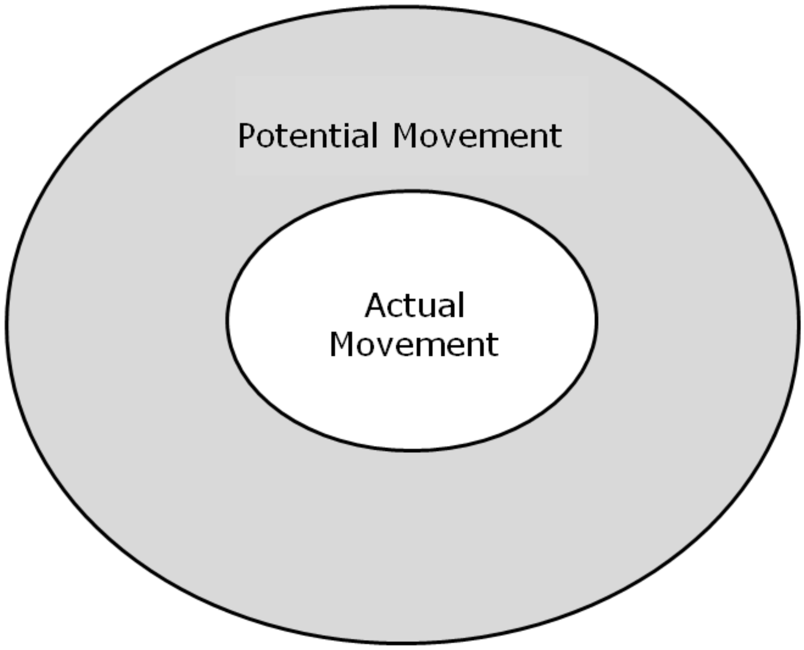

Figure 1. Difference in actual and potential movement (Gudmundsson 2005).

The difference in ”size” between realized and potential movement in Figure 1 illustrates the difference between how much travel would be possible compared to how much is actually done. The potential to move does not always meet the need to move, sometimes resulting in excess capacity when at other times there is too little. The available potential both enables and constrains the actual movement. (Gudmundsson 2005.)

Potential movement can be further divided into a potency (or supply) side and a tendency (or demand) side. When the two overlap, actual movement may be produced. Potency reflects the transport system's potential capacity, and tendency the need or desire to move. This need is produced and conditioned by a range of socio-economic factors, the influence of which controls the physical separation of activity spaces, and the preferences, roles, lifestyles and activity patterns of individuals. Together these factors create the pressure (tendency) to release the potential into movement. (Gudmundsson 2005.) However, supply and demand do not always meet, proven by idle seats in some vehicles and people standing in the aisles or corridors in others. With the help of intelligent transport systems it may be possible to even out the capacity in time and space.

Once the quantity of travel needed is satisfied, quality becomes a critical factor. Safety, comfort, reliability, privacy, continuity, and even ”greenness” may be important choice parameters in everyday mobility (Nilsson and Küller 2000). If, for example, buses are felt to be unsafe and appear dirty, they are not used as much as they could be even if the bus service ran fast and cheaply between the desired locations. Qualities are not separate from potential movement but should rather be seen as important attributes of it. (Gudmundsson 2005.)

The qualitative dimensions of travel are hard to capture fully. Some of these aspects are readily quantifiable like travel time, emissions and ITS services available, while others like insecurity of travellers and aesthetic qualities are not. (Gudmundsson 2005.) For some travellers, trade-offs are made on a daily basis, while for others choices of particular modes or routes are deeply entrenched (Jensen 1999). Moreover, finding the value for the qualitative factors that affect people's choices is very hard, as there are plenty of different opinions for the most important factors affecting travel amenity. In a study on social security in public transport in Helsinki, 24% of travellers said they could use more public transport provided it was safer (Forsblom and Happonen 2005).

Mobility sustains the wider economy and vice versa and thus enjoys plenty of investment. Internal mobility investments cover infrastructure, but mobility has external impacts affecting, for example, the environment in terms of air quality and pollution. To be internally and externally sustainable, investment should help increase mobility, but it can be difficult to define where the money for improvements should go. Insufficient system investments may in some cases slow down growth in wellbeing or even lead to breakdown. However, maintaining extensive system potential might not be economically sustainable. (Gudmundsson 2005.) Building new lanes on congested roads is expensive and may not help much, as for example at least half of all metropolitan area congestion has been assessed to be due to operational rather than infrastructural problems (Button et al. 2006).

Gudmundsson's analysis proposes a very rich conceptual description of mobility. It covers potential and actual movement at micro and macro levels. To realize this idea, extensive amounts of data would have to be collected, and importantly, many of the measures to be monitored would have to be estimated. (Gudmundsson 2005.)

In conclusion, mobility is willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people's and road users' attitudes, opinions and choices in their daily travelling and movement. The concept of mobility is hard to fully define, and is often reduced to transport or confused with accessibility or efficiency.

2.3. Personal mobility

Individuals' mobility patterns are based on a number of conscious and unconscious choices. It has frequently been noted that banal travel patterns tend to repeat themselves routinely, continuing the same pattern from day to day, week to week and year to year. (Pendyala et al. 2000.) Modern everyday life is no longer characterized by a connection to territorial anchored communities, but in a much higher degree of mobility between a numbers of different communities (Freudendal-Pedersen 2005). It is common nowadays to choose workplaces and activities based on personal interests, not on what is available nearby, thus creating a need to commute more. Gärling and Axhausen (2003) stated that the reason for repeating behaviour may simply be that the intention, like driving to work, is formed repeatedly.

An important reason for this interest in habitual travel choice is its bearing on travel demand management strategies. A choice that is non-deliberate may in fact be difficult to influence with rational arguments like increased costs or pollution, since the person making the choice tends to discount relevant information. (Gärling and Axhausen 2003.) If these habits are desired to be broken and people encouraged to try other modes and ways of travel, it should be figured out how these choices can again become deliberate and rational.

Freudendal-Pedersen (2005) claimed that structural stories are an essential part of how individuals understand and explain their mobility in everyday life. A structural story contains the arguments people commonly use to legitimize their actions and decisions. The individual view expresses structural stories as universal truths, agreed upon by all. A structural story is used to explain the way we act and the choices we make when exercising our daily routines. It is a guide to certain actions that, at the same time, emancipate us from responsibility. For example, when an individual has to look on downsides and risks connected to mobility like traffic-caused pollution, one becomes troubled and constructs a structural story instead, using impersonal “one” instead of “I”, like “When one has children one needs a car.” An individual often chooses knowledge that does not interfere with everyday life and frees them of responsibility, even when there could be other options that would not necessarily mean many changes to the person’s normal routine. (Freudendal-Pedersen 2005).

One part of this reluctance to consider new modes of travel and new routes is that the person has already gathered lots of information about his/her normal route with the vehicle most used , and travelling thus seems “easy”. The relationship how strongly past behaviour or habit and intention determine behaviour is assumed to be reciprocal (Triandis 1977): the stronger the determinant habit is, the weaker the determinant intention is, and vice versa. The more frequently a choice is made, the more habitual or script based it becomes (Gärling and Axhausen 2003.) Thus, if the route or vehicle were to be changed, the person would need to seek information and construct new routes and evaluate alternatives, bringing psychological stress upon him or her. It may be assumed that the cost of searching for and constructing new alternatives is generally too high and expected gains with new alternatives too uncertain. (Gärling and Axhausen 2003.)

Once formed, personal travel patters seem hard to alter, thus affecting the use of different travel modes. The reasons why people choose their mode of transport are difficult to find. The reasons can be sought with the help of concepts of personal mobility and mobility culture. Transportation is built, used and developed by people. This human factor brings with it a need for clarifying the concept of personal mobility and how it could be made operational so as to assess and monitor the results of policies that try and aim to provide it. (Gudmundsson 2005.)

Firstly, in any given population some people are more susceptible, or ready to change their travel behaviour than others. This partly relates to more subjective factors such as peoples’ attitudes, perceptions and level of confidence towards their current travel mode choices, and towards alternative travel choices, as well as their wish to actually change their travel mode behaviour. In this context, if people currently have negative perceptions and attitudes towards alternative modes, little or no confidence in using other modes, or see no reason to change modes, they will be unlikely to do so. The role of mobility management interventions should be to attempt to change these attitudes and perceptions, and instil confidence in a positive way in order to motivate people to try out, and ultimately adopt new travel mode behaviours. (Carreno et al. 2010)

Gärling and Axhausen (2003) also addressed the problem why private car use cannot be easily suppressed. The car is an attractive alternative to many, and there often are obstacles that prevent switching to other modes. Thus, drivers may be unable to switch even though they are motivated to do so. Unavailability of alternatives is of course a main obstacle in many cases, or if they have a mobility impairment that prevents them from switching car trips to traditional bus services, cycling or walking. Yet, inertia or habit may also play an important role. It increases the transaction costs since switching to another mode makes it necessary to learn new routines. Furthermore, searching and processing information about alternatives are reduced. Hence, important changes may go unnoticed such as, for instance, attractive alternatives becoming available. In this instance mobility management interventions alone would be unlikely to change people's travel behaviour, and ”harder” more infrastructural measures would have to be implemented first or simultaneously (such as the addition of new bus services, or demand for responsive services for mobility-impaired people). The role of mobility management would be more supplementary in ways such as increasing awareness of these new services (via travel awareness campaigns), or provision of free tickets to entice people to try new services. (Carreno et al. 2010; Gärling and Axhausen 2003.)

Accordingly, the implications are that any mobility management intervention is likely to affect people in different ways based on their susceptibility to change behaviour and stage position within the behavioural change process. Further, evaluations that focus on behavioural change *per se* would not detect any of the subtler attitudinal and perceptual changes that would also occur as people progress to later stages of readiness to change (Carreno and Welsch, 2009).

In order to successfully change people's travel behaviour, it is essential for practitioners and policy makers to understand the underlying processes necessary for behavioural change to occur, and to use this knowledge in both the design and evaluation of mobility management projects. (Carreno et al. 2010.)

The EU-funded project MaxSem provides a theoretical framework describing the behavioural change process and explains individuals' readiness to change travel mode by categorising them in one of four stages: (Carreno and Welsh 2009)

Stage 1: Pre-contemplative stage. Individuals in this stage typically make most of their trips by car, are quite happy with the way they currently travel (i.e. as car drivers) and at the moment have no wish or desire to change to another mode, or feel that it would be impossible for them to do so at the present time, whether this be for subjective or objective reasons.

Stage 2: Contemplative stage. Individuals in this stage also typically make most of their trips by car, but are not as content with their current travel behaviour (as pre-contemplators). They would like to reduce their level of car use and change to another way of travelling, but at the moment are unsure of which mode to switch to, or perhaps don't have enough confidence to do so. They are not really sure which alternative mode(s) they could use, or when they will begin replacing their car trips.

Stage 3: Preparation/Action stage. Individuals in this stage also typically make most of their trips by car, but have decided which replacement mode they intend to switch some or all of their car trips to, have the confidence to do so and may have already tried this new mode for some of their trips.

Stage 4: Maintenance stage. Individuals in this stage typically make most or all of their trips by non-car alternatives (public transport, walking, cycling etc.). These can either be people who do not own or have access to a car for their trips (and are therefore dependent on non-car modes for travelling), or people who do own/have access to cars but for various reasons use them very infrequently, or not at all.

These stages can be viewed as a series of steps leading up to the final step of actual behavioural change. Although the steps are fundamentally different from each other and follow on from each other in a logical way, it is possible for some stages to be missed (for example pre-contemplators could move directly to preparations/action or maintenance stages) or backward movement (stage regression) to occur. (Carreno et al. 2010)

In order for people to progress from earlier to later stages, key threshold points have to be ”satisfied”. So for pre-contemplators to become contemplators the key is the formation of a ”goal intention” which means that they have to recognise that their current level of car use is ”problematic’ and want to reduce it. For people to form a goal intention, several factors (or constructs) are known to be important, although the importance of each construct will differ on an individual basis. For example, for some people the key factor may be for them to ”feel bad” about their current level of car use (negative affect) and for others they may feel that to reduce their car use at the current time is not a realistic option (goal feasibility) etc. Once in the contemplative stage, they then have to identify which would be the most suitable option (which mode) for them to reduce their car use, and feel sufficiently positive towards (attitudes towards different behavioural change strategies) and/or confident (perceived behavioural control) to use this alternative non-car mode, and a behavioural intention is formed. The transition into the final maintenance stage involves individuals making definite plans and/or possibly trying out the new mode choice, which is conceptualised by an implementation intention, and ultimately this new behaviour becomes their new normal dominant mode behaviour. (Carreno et al. 2010)

2.4. Mobility management

Mobility is in many ways an ambiguous notion. It has a strong physical presence while it is also infused with meanings, aspirations and potentials. It is instrumental to serving other needs, but it has effectively transformed modern culture in its own image. It sustains the economy, but to do so it requires substantial inputs of resources and time. Such ambiguities should be confronted squarely in order to avoid a ”mobility policy” to disregard them. If a comprehensive concept of mobility were to be made operational in terms of concrete measures, targets and indicators, it would reflect very important elements of modern life and society, in a way that is not available today, and it could have several uses. First, it might be used to inform the public directly about important aspects of their daily life situation and choice options. Secondly, it could be used to assess the fulfilment of mobility policy objectives, and to confront and compare these with the already established objectives — for example in environmental protection or traffic safety, to identify trade-offs and possible synergies. (Gudmundsson 2005.)

Mobility policy development has gained popularity worldwide, being defined as mobility management. Interest in mobility management type projects[1] has been growing worldwide as a potential solution to global environmental problems (Carreno et al. 2010). The European Platform on Mobility Management (EPOMM) provides the following definition of Mobility Management:

> “Mobility Management is a concept to promote sustainable transport and manage the demand for car use by changing travellers’ attitudes and behaviour. At the core of Mobility Management are "soft" measures like information and communication, organising services and coordinating activities of different partners. “Soft” measures most often enhance the effectiveness of "hard" measures within urban transport (e.g., new tram lines, new roads and new bike lanes). Mobility Management measures (in comparison to "hard" measures) do not necessarily require large financial investments and may have a high benefit-cost ratio.”

Carreno et al. found that the mobility management type of intervention works, changing individuals’ modal choice behaviours. Evidence to support the effectiveness of mobility management strategies is increasingly well documented, although there remain some inconsistencies in the actual extent of changes in behaviour reported. (Carreno et al. 2010.)

Schreffler et al. (2010) defined four ways to affect attitudes with mobility management:

1. Successful campaigns adapt a social marketing (rather than solely a marketing communications) approach.
2. Far greater emphasis is given to the campaign planning stage and especially "upstream" marketing to engage stakeholder support.
3. The design incorporates a continuous dialogue between the campaign team and target audience so that there is a clear understanding as to why people do not travel sustainably, that is the barriers to change.
4. Increasing attention is paid to the campaign legacy-achieving longer lasting impact for your investment.

The term "mobility management", as used in Europe, is more narrowly focused on measures such as information, marketing, partnerships, communications, and promotion of sustainable modes. (Schreffler et al. 2010) In order to persuade both policy makers and practitioners to adopt mobility management strategies there is a need for these decision makers to accept, understand and be able to predict (with confidence) their likely effectiveness. To satisfy these requirements there is a need for a greater understanding of how mobility management interventions affect individuals' modal choice decisions and robust evaluation techniques that will allow any behavioural changes to be observed. (Carreno et al. 2010)

An international comparison of metropolitan areas suggests that even under the same regulatory framework cities have options for shaping their own future developments. For example some cities like Copenhagen, Groningen or Münster have well-known "good practices" for communities with high shares of bicycling usage, while others are "transit metropolises" like Munich, Curitiba or Tokyo. Additional to national and international policies, thus local policies and traditions become important for shaping a more sustainable transport system in metropolitan areas. (Klinger et al. 2010.)

In one of the most recent and comprehensive reviews of UK and international evidence, Cairns et al. (2004) concluded that if mobility management (or ”soft transport policy”) measures were given greater policy priority in the UK than at present, they had the

”potential” to achieve a reduction in peak urban traffic of about 21% (off peak 13%), and a UK nationwide reduction of all traffic of about 11%.

The report also considered the potential impacts of individual mobility management measures and suggests that at a local level individual mobility management measures such as workplace travel plans have the potential to achieve between a 10-30% reduction in solo car use, school travel plans between 8-15%, and personalised travel planning initiatives between 7-15% (Carreno et al. 2010).

2.5. Mobility impact assessment methods

People’s mobility is restricted by their location, origins and destinations. This is the case especially in commuting, which often constitutes a major part of people’s travel. The choice of main commuting mode restricts the mobility options for the rest of the day, and commuting suffers from much more time-related and space-related constraints than any other trip type as the origin, destination and working hours are mostly fixed. Therefore in mobility analysis, it is standard practice to make a difference between commuting and other trips. (Kulmala and Rämä 2010.) Still, even small impacts on individual people’s mobility trigger larger impacts on a larger scale: more people changing for example to bicycles creates more demand for good bicycling routes.

In research, mobility is often mixed with traffic and accessibility. Public policy has traditionally been aimed at improving accessibility, and this may mean providing options to reach different locations, or meeting a particular need, rather than improving transportation *per se*. As access can be enhanced by moving the objects like jobs and schools, by making it easier to reach the existing ones, or by providing a non-transportation means such as a telecommunications alternative, changes in accessibility are easier to plan and create. Accessibility has also the useful pragmatic advantage that it is easier to develop quantitative indicators to measure accessibility than it is for mobility. It should be noted that neither the mobility nor the accessibility concepts are policy neutral. Policies aimed at extending mobility implicitly favour travel over other uses of resources, but are neutral as to favouring any particular destinations. Thus mobility leaves the potential trip-maker with decisions as to where to go, whereas accessibility favours some destinations over others. (Button et al. 2006.)

2.5.1. Measurement in general

Mobility and movement potential are impossible to measure directly. In research, one has to use surrogate measures such as transport mobility, which is revealed mobility in terms of the benefits derived from travel activities (Spinney et al. 2009). Although mobility in itself has not been studied much directly, many studies cover some of its elements.

When studying mobility impacts of ITS, there are not many methods to choose from. The iCars Network project (Rämä et al. 2009) provided an impact assessment catalogue of Intelligent Vehicle Systems evaluation methods and their use in assessing different traffic impact areas. For mobility, only a few studies were found, and these were based on two methods: TDs (travel diaries) and GPS (Global Positioning System) tracking. Questionnaires and interviews are, of course, usable methods as well when the number of variables and test participants are limited. The small amount of used methods found could be related to the small amount of research done on mobility impacts of ITS, and consequent shortage of developed methods.

2.5.2. Travel diary

TDs collect data by recording a detailed log of how people allocate their time during the day, focusing on transport. Typically diaries are designed to capture information on quite a lot of things like the origin and destination of the trip, departure and arrival times, modes of transport used, and whether or not the traveller was accompanied. (Rämä et al. 2009.) The task of filling out the diaries is left to the traveller.

The limitation of TDs is that they should be kept simple in order to get a better response rate. Therefore not all relevant aspects, such as rationale for mode choice in individual trips, are covered in detail. Also, since a TD concerns self-reported behaviour, there is no guarantee on the correctness and completeness of the responses as the behaviour is reported in the aspect of subjective mobility. As defined by Collantes and Mokhtarian (2007), subjective mobility could be defined in terms of a subjective assessment of the amount of travel one does. The association between quantitative reports of mobility and personal qualitative judgments of those amounts is not deterministic: subjective assessments of the same objective amount of personal travel will in general vary across individuals. Thus the same trip can be reported as “long” or “short” depending on the individuals. (Collantes and Mokhtarian 2007). This is why qualitative self-assessment (for example scales like long/short) should be used only with caution.

The quality of the TD study depends on the selection of respondents with regard to the sample size, the coverage of trips and other relevant factors, participants’ willingness to respond and their accuracy in the answers. With a large enough sample size, satisfactory accuracy with statistical significance can be obtained. (Rämä et al. 2009.) Despite its many advantages, collecting and using mobility data also poses ethical challenges and may negatively impact privacy and personal integrity. Therefore it is important to address privacy concerns when collecting and using mobility data. (Sochor and Koutsopoulos 2009.)

GPS tracking can be used as a supportive system with TDs to reduce the gap between subjective and objective mobility, or by itself (Nimmo 2009). Tracking data cannot be used alone, however, as researchers would need to know labels to certain places like home, workplace and frequently used shops in order to employ the data in the best way possible. In addition, logging data can only cover trips made by the vehicle being logged. (Rämä et al. 2009.)

2.5.3. GPS

The main elements in the tracking technology are a positioning system (for example GPS) and method for data transfer (for example GSM, GPRS and 3G).

The GPS is a satellite-based radio navigation system that provides means of determining position, velocity and time around the globe. GPS was designed and paid for by the U.S. Department of Defence. The GPS constellation consists of 24 satellites arranged in six orbital planes with four satellites per orbital plane. The constellation is designed to provide worldwide coverage 24 hours a day. The observation of at least four satellites simultaneously will permit determination of the 3D coordinates of the receiver. (Zhao 1997.)

The GPS signal can be received by various devices such as navigators, mobile phones and separate tracking units. The receiver picks up the GPS signal and, based on calculations made with the data from signals, the location of the device can be determined. Accuracy available to civilian use was limited before the year 2000 with selective availability (El-Rabbany, 2006.) According to Salmenperä (2004), the accuracy of satellite positioning varies from 1 to 10 metres. The accuracy of GPS is affected, along with functionalities of satellites, by atmospheric effects and the tracker's environment. The satellite positioning system is interfered with by temperature, pressure, humidity and free electrons that have an effect on the speed of satellite signals (Goel 2008). Buildings, tunnels, parking halls etc. on the environment can obstruct the signal (El-Rabbary 2006).

Developments in GPS have revolutionised the potential to improve the accuracy and precision of travel data. Building on the use of GPS as a means to improve existing data collection efforts is a growing recognition of the potential of GPS to open up new possibilities in understanding travel behaviour. According to Greaves et al. (2010), there are three main reasons for this. First, GPS provides the potential to extend the period of data collection with little additional respondent burden. Second, the easy integration with digital-based maps coupled with developments in web-based technology has facilitated the potential to go back to participants to both confirm that trip details are correct and prompt them for information not directly discernible from GPS data such as trip purpose, who was driving, number of passengers etc. (Auld et al. 2009; Doherty et al. 2006). Third, the capability to provide new data elements (for example speed) opens up new avenues for investigation of driving behaviour.

Other positioning systems in use are the Russian GLONASS and the Chinese regional satellite system Beidou, but they do not yet offer serious global competition to GPS. GLONASS has 21 satellites in space, and is open for military and civilian use. GLONASS receivers are more expensive and larger than in GPS, as the satellites transmit its own carrier frequencies. GLONASS system includes ground stations and control centres mainly in Russia. The Chinese Beidou has fewer satellites in space compared to GPS and GLONASS, offering limited coverage only to China. (El-Rabbary 2006.)

Two new systems are under development. The European project Galileo is designed for providing different kinds of service levels from open-access to commercial, safety and public. When ready, the Galileo system will consist of 30 satellites and ground and user segments. The ground segment includes tracking stations and control centres worldwide. The first Galileo experimental satellites were launched in 2005 and 2006 and the whole system was designed to be ready in use in 2010. (El-Rabbary 2006). The project has suffered delays, and in February 2011 the first satellite was still 6 months away from launch. When completed, however, Galileo will be the first complete civil positioning system. (European Space Agency 2011). The first of three satellites of the Japanese Quasi-Zenith Satellite System QZSS was launched in September 2010. QZSS aims at improving the positioning accuracy of 1 meter to centimetre level, compared to the conventional GPS error of tens of metres, by transmitting support signals and through other means. QZSS is aimed to enhance navigation in Japan. (Japan Aerospace Exploration Agency 2010.)

In cellular positioning, the distance between the cell phone and its receiving antenna is calculated (Denys et al. 2007). The accuracy of cellular positioning depends on the density of antennae in the area. The maximum is 10 metersm, but on average the situation depends on the amount of available antennae and is often less optimal: for example in a densely populated country like Belgium, the average accuracy levels are estimated to be between 400 m and 1 km. (Goel 2008.) Also it is often costly to obtain the position information from service providers (Denys et al. 2007).

The use of data gathered during a study is under restrictions in many countries. In Finland, the Personal Data Act restricts the use of person-related data gathered in studies. The objectives of the act are to implement, in the processing of personal data, the protection of private life and other basic rights which safeguard the right to privacy, as well as to promote the development of and compliance with good processing practice. (Ombudsman 1999.)

However, the legislation varies in different countries. Rainio (2003) mentions that reformation of laws connected with tracking has been ongoing for about a decade. For example, in the United States there are strict instructions for emergency call tracking, but tracking in business use is less regulated. Japan recently updated its privacy protection acts, and the EU has been forming directives for cellular positioning laws in the Member States. Overall, tracking legislation is still under construction in many countries. (Rainio 2003; Tervo-Pellikka 2000). Privacy policies and regulations should be considered before conducting any study.

To sum up, it is quite difficult to measure mobility in itself but many studies cover some of its elements, mostly related to actual movement. Usable measurement methods include questionnaires, TDs and GPS tracking.

2.6. Mobility impacts of ITS

ITS can affect mobility in many ways. By giving out real time information and guidance in the right place at the right time, ITS can help people make more informed travel choices. At the same time their mobility attitudes can be altered. Mobility potential can be used more effectively as telematic services make the use of different travelling modes easier. Moreover, ITS can affect the trip both before and during travel, as well as in the long run as small daily choices change people’s mobility conduct. (Innamaa 2010.)

The use of ITS is becoming an increasingly important part of traffic and mobility, changing people’s habits and the way they use transport. Along with a definition of ITS:

“ITS are the marriage of information and communication technologies (ICT) with the vehicles and networks that move people and goods. They are called “intelligent” because they bring extra knowledge to travellers and operators. In vehicles, ITS systems help travellers reach their destination safely with minimum delay and environmental damage. On the road network, ITS provide tools for dynamic traffic management keeping the network in efficient operation at all times." (Kulmala 2010.)

Little research has been done on the mobility impacts of ITS. Impact assessment studies of ITS have traditionally focused on safety and the environment. However, the EU's iCars Network project pointed out mobility impact assessment as an important area for future development (Rämä et al. 2009). They assumed that the demand for mobility impact assessment will increase in the future, based on the ability of ITS applications to affect mobility and the strong willingness of end users to pay for improved mobility. Some studies assessing mobility impacts of ITS were found and collected by the iCars Network.

ITS services are already used daily by many drivers with navigators and by public transport users with trip planners. Aguilera and Guillot (2010) noted that ITS will not necessarily just shorten and reduce the trips made. Trip frequencies, purposes, the modes and routes involved may change, but the trips, in general, are still made. In addition, ITS can make it easier to reach one's destination, and thus generate trips that would not be otherwise made as the traveller would not be confident of the route. Finally, the links between ITS and trips cannot be considered in isolation from the organizational, economic and societal context in which they perform a coordination function. (Aguilera and Guillot 2010.) Rouphail et al. (2010) showed that having access to pre-trip information might not always be beneficial if it is not updated en-route, especially in large networks where traffic conditions may change between the departure time and the time an impacted area is reached.

Manelius (2010) studied the effects of real-time traffic information on drivers using a questionnaire. In the study, ten variable message signs (VMS) were installed in the Tampere region to provide real-time traffic information and to help drivers adjust their route choice in case of disturbances. Observance of VMSs was high, almost all participants seeing one (98% of passenger car drivers and 99% of heavy truck drivers). It was found that the more repeatedly people see traffic information, the more it affects them. Two thirds reacted to the messages by increasing their alertness and slowing down, and one third rerouted if they got a message of congestion ahead on their route. The most common reasons for information having no effect on the driver were that other routes were not believed to be any faster and road works were not believed to be disrupting traffic. (Manelius 2010.)

The Tampere research mirrored a study carried out in the UK in 2007. The Highways Agency's study examined the level of public understanding of VMS and the change from the similar study conducted in 2006. Around 60% of respondents assessed that they had changed their driving behaviour in some way after detecting a VMS message. People travelling on a regular trip to and from work or for employer business were more likely to see a speed restriction that those travelling for leisure (52% compared with 42%). The most common reaction was slowing down and growth in alertness. Only 3% of people changed their route after detecting the message. Still about 40% of people who saw the sign did not react in any way, their number rising from 26% in 2006. The reason behind this increase was perhaps that the service had become familiar to the users, and some early reactions had only been novelty effects. (Highways Agency 2007.)

Intelligent Speed Adaptation (ISA) was tested in Stockholm in 2003 by investigating whether ISA is usable for the quality assurance of transport services (Myhrberg 2008). The technology used was found not to be fully mature for data logging and ISA. Partly because of this, two out of three participants felt that the service impaired driving enjoyment, and driving with ISA was regarded as effortful and frustrating. Among other problems, they felt they were holding up other vehicles. (Myhrberg 2008)

In a field study in Finland, Laine et al. (2007) assessed the effect of speeding warning in mobile phones by questionnaire and interviews. The results were encouraging as half of the drivers reported having changed their driving performance to safer behaviour, in that they had started to follow the speed limits more and to drive slower. The users felt that the service was there to improve their own and other road users' safety, and were even ready to pay for the service. However, the service was also felt to be "nagging" and disturbing.

Vonk et al. (2007) studied the effect of navigators on mobility. The study showed a reduction of 16% in kilometres when travelling in an unfamiliar area with a navigator compared to driving in a similar situation with conventional navigational aids like a map and direction signs. Also the mean speed of drivers increased somewhat. The study indicated a positive effect of navigation systems on traffic safety. (Vonk et al. 2007).

Studies have been carried out especially in the field of public transport, where one focus is to try to grow the number of people using public transport. Many of these studies, however, use web-based and paper questionnaires that may give a false picture. A study of passenger information system in Espoo was nonetheless successful. The system was found to improve comfort, decrease experienced uncertainty, improve the choice of line and mode of transport, and moreover to enable better utilisation of waiting times. The system was well accepted by users, as 88% of interviewed passengers evaluated the system as good or very good and 72% were in favour of expanding the system. (Pesonen et al. 2002.) More accurate information about public traffic encourages the use of public transport.

To answer “how” people choose their mode of transport is a difficult task. Cao and Mokhtarian (2005) described travel behaviour and modal choice as an individual adaptation process, and stated that travel attitudes, personality, and lifestyle influence the adaptation process (also Carreno et al. 2010). Harder still is to define what makes people change their mode of transport. Some people are more susceptible, or ready to change their travel behaviour than others. This affects the ITS‘s potential to impact mobility. (Cao and Mokhtarian 2005.)

The change of travel behaviour relates partly to more subjective factors like peoples’ attitudes, perceptions and level of confidence towards their current travel mode choices, and towards alternative travel choices, as well as their wish to actually change their travel mode behaviour. People are unlikely to change their mode of transport for example from private car to a bus if they currently have negative perceptions and attitudes towards public transport, little or no confidence in using other modes, or see no reason to change modes. The implications are that any intervention is likely to affect people in different ways based on their susceptibility to change behaviour and stage position within the behavioural change process. (Carreno et al. 2010.)

In conclusion, ITS services have proven to have some effect on people’s travel behaviour. Changes can be small on an individual level, but generate larger changes on the traffic flow level like on traffic volumes, transport network throughput, safety and emissions. Already some services are thought to be worth paying for, indicating their importance for subjective mobility.

3. RESEARCH ENVIRONMENT AND METHODS

3.1. TeleFOT – Study overview

Field Operational Tests (FOTs) are a tool to provide reliable results on the long-term impacts of vehicle safety systems. Two types of FOTs are used in the TeleFOT project: large scale FOTs (LFOT), which involve up to several hundreds of users, who drive their own vehicle and use their own devices, and detailed FOTs (DFOT), where aspects which cannot be addressed in the large scale FOTs are assessed using instrumented vehicles and possibly human observers. During LFOTs, the users generally drive for an initial period without the studied functions, in some cases with a minimal set of (other) services available, only logging reference information. Next they start using the studied functions. This is known as the "within subjects" study design, but also a "between subjects" study design is used in some of the national FOTs, comparing results to a reference group running simultaneously throughout the test. (Scholliers et al. 2009.)

The TeleFOT project aims at assessing the impacts of telematic functions provided by nomadic and aftermarket devices, such as navigation support and speed limit information, on traffic safety, user mobility and the environment. As much as 3000 test users will form the test communities of Finland, Sweden, the UK, Italy, France, Germany, Spain and Greece. (Gaitanidou 2010.) The functions to be tested are static and dynamic navigation (NA), traffic information services (TI), speed alert (SA) and speed limit information (SI), green driving functions (GD) and eCall/bCall implementations. TeleFOT is focused on five main topics including safety, mobility, efficiency, the environment and user uptake. (Scholliers et al. 2009.) This study concentrates on findings from the Finnish LFOT.

The various large and detailed FOTs in TeleFOT are being implemented into nine different Test Sites across Europe. In order to coordinate all the activities in the different FOTs, TeleFOT has grouped the Test Sites into three different Test Communities: (Gaitanidou et al. 2010)

- Northern Community: Finland and Sweden
- Central Community: France, Germany and UK
- Southern Community: Greece and Italy

The TeleFOT project will collect information from a wide range of data sources in order to analyse the impact of nomadic devices on driving behaviour and generally on traffic. Data sources include: (Scholliers et al. 2009.)

- In-vehicle GPS and acceleration loggers (data logger) specifically installed for data collection
- Available logs on service use, for example server logs on information requests and broadcasted data, logs from the nomadic device or navigation program where available
- Traffic and weather information
- Various additional sensors in instrumented vehicles for detailed testing
- Questionnaires for collecting subjective data
- Travel diaries

Vehicle-based FOTs use in-vehicle Data Acquisition Systems (DASs). There is no standardised way to get all relevant data on position and vehicle conditions from the vehicle. The TeleFOT project uses DASs from different providers which log basic motion using satellite positioning and acceleration sensors. The DAS collects GPS coordinates, velocity, heading and number of satellites used in the solution. (Scholliers et al. 2009.)

All data will be stored in the central data system designed in the project and provided by Emtele. The data collection system consists basically of two databases: one with the (raw) collected data from the DASs and one with enriched data. The database with the raw data holds the information collected by the DASs as a measure of precaution, should there be errors in post processing. The database with enriched data contains processed DAS data and combines the DAS data with other information sources, such as service logs and user questionnaires. The data collected with the DASs are processed and filtered in order to calculate a number of performance indicators, such as mean speed or journey travel time, and make the data available to the analysts. This pre-processing includes e.g. separating the location data per road segment and per journey, and calculating the relevant indicators (for example average speed over road segment), as well as assuring the data quality of the collected data. During this processing phase, the position data will be (map) matched to the road network using a service provided by the map provider NAVTEQ, a partner in the TeleFOT project. (Scholliers et al. 2009.)

Information is also needed on how the driver has been using the tested function, whether the driver is the actual test user and for example whether the device was properly installed. This information has in most cases to be provided by the driver. For this, travel diaries are used: the journeys made by the driver will be calculated using the database and the driver is requested to provide additional information through a web questionnaire. Weather and traffic data are collected from the test sites to support analysis. (Scholliers et al. 2009.)

The functions and services tested in the Finnish LFOTs cover the whole country. However, the majority of test users have been recruited from the Oulu, Tampere and Helsinki regions due to partner organisation locations and for customer support. Participants were recruited via an online site. Participants were required to have a vehicle with OBD-II interface and Nokia E or N series cell phone with GPS. (Gaitanidou et al. 2010.)

Privacy-related aspects have been taken into account ever since developing the data collection system. Personal data, such as test participant identity and contact information, are maintained separately from the vehicle data collection. The general database holds only anonymous user IDs. The driver-level issues are not given outside the TeleFOT consortium, and researchers get only anonymous data. The results are analysed in larger sets, divided in e.g. services and countries. Thus results by single test participant are impossible to distinguish from the final results. (Scholliers et al. 2009; Innamaa 2011.)

3.2. Mobility impact assessment in TeleFOT

In TeleFOT the actual mobility assessment analyses will focus on changes in:

- Individual travel behaviour – trip decision, choice of mode, choice of route, etc.
- Overall mobility – travel kilometres and hours. (Gaitanidou et al. 2010.)

The emotional and psychological benefit of movement is also studied to some extent in terms of trip quality. All analyses will be carried out across the sites, but also by site as the applications and study designs are different. Most analyses are quantitative, aiming at numerical estimates of the impacts, but some will also be qualitative. The estimates will be subject to standard statistical tests of significance and validity. The analyses will be complemented with context and background information to clarify and interpret the findings. (Gaitanidou et al. 2010.) Mobility research questions are presented in Appendix I.

In TeleFOT, TD was developed to fulfil the information needs in order to address research questions and hypotheses related to mobility impact assessment. The TDs are used in large scale FOTs only, as the experimental design of the detailed FOTs is not suitable for mobility impact assessment. Test fleets of professional drivers using TeleFOT functions only during work are excluded from the mobility impact assessment. The TD is filled in paper form, one paper a day. Diaries are collected once in the before-phase of the FOT (tested functions not yet available) and two or three times in after-phase (tested functions available to participants) depending on the length of the FOT. The length of each TD data collection period is 1 week. More specifically, the TD data collection is timed as follows (Gaitanidou et al. 2010.):

- First week: To be collected during the before-phase of the FOT. Participants do not have the tested functions available at this point.
- Second week: Approximately 2 months after the after-phase of the FOT has started. Participants have tested functions available.
- Third week: Approximately 6 months after the after-phase of the FOT has started.
- Fourth week: At the end of the after-phase for FOTs that last for 8 months or longer.

A supplement to the TD (Appendix II) is filled in during the after-phase TD data collection periods to collect essential information about major changes in the mobility needs and possibilities of the test users and their families due to factors other than TeleFOT functions (one questionnaire per week). This information is needed for interpretation of the results and to minimise extra variance.

3.3. Travel diary

The TDs (Appendix II) are used to collect information on participants' journeys and their choice of travel modes. In addition, the TDs aim to record the participants' use of the different TeleFOT functions and devices before, during, and after the trip. The main information to be collected by the TDs is listed below:

- Origin and destination of each trip
- Time at which the trip started and time at which it ended
- Length of trip (in 100 metre accuracy)
- Modes of travel in the order used
- Primary mode of transport
- Purpose of trip.

A trip is defined as moving from one place to another for an end purpose. A trip can comprise one or more modes of transport. Most trips include a walking part. A trip that includes only walking should also be recorded. However, short walking distances (e.g. less than 5 minutes) at the origin or destination should not be included. Those travelling on a predefined route (like bus drivers) should only log trips that are not related to these predefined route selections. The trip to and from work should be logged. The survey day starts at 4 am and ends at 3:59 am the following day. Trips are logged in the chronological order (sequence) in which they were made during the day.

Origins and destinations were coded in the TD according to the 12 options given in Table 1. If none of the options corresponded to the origin or destination of the trip, option 13 "Other location" could be chosen together with a short description of the location.

Table 1. Origins and destinations.

1	Permanent residence (own home)	8	Supermarket, shopping centre or other retail location
2	Other residence (including holiday/weekend residence)	9	Location related to personal business (bank, office, doctor, etc.)
3	Own place of work	10	Restaurant, cafe or similar
4	Own school or place of study	11	Place of leisure activities
5	Business trip related location	12	Hotel or similar
6	Place to pick up person or goods	13	Other location, describe
7	Day care, children's school		

For mode of travel, the test participant was offered 17 predefined travel modes (Table 2). If the mode of travel did not fit the offered ones, option 18 "Other form of transport" could be chosen together with a short description. One mode category could include more than one mode of travel (for example mode 1, hereinafter called *pedestrian*) or one mode of travel could be divided into two categories differentiating the role of the participant (mode 3 as passenger in a passenger car or van and mode 4 as driver in a passenger car or van).

Table 2. Travel modes.

1	Walking, running, kick sled, kick bike, walker, wheelchair, skis, rollerblades etc.	9	Train
2	Bicycle	10	Taxi, inva-taxi
3	Passenger car or van, as passenger	11	Aeroplane, helicopter
4	Passenger car or van, as driver	12	Motorcycle
5	Local bus (including service lines), school transport	13	Moped, moped car
6	Long distance coach	14	Skidoo, all-terrain vehicle
7	Metro	15	Water transport (boat, ship, ferry)
8	Tram	16	Truck/lorry
		17	Tractor/self propelled, (road maintenance vehicles etc.)
		18	Other form of transport, describe

For purposes of travel the test participant was offered nine predefined purposes plus category “other” that also required a description (Table 3). Participants were given instructions that the purpose of a trip home is the original main purpose for leaving home. An example of the use of purposes is given in Table 4.

Table 3. Trip purposes.

1	Commute to work, commute home (or to other residence)	5	Personal business (to/from)
2	Business trip (usually a work related trip paid for by one's employer, to/from)	6	Lunch/eating/restaurant visit (to/from)
3	Trip to/from school, place of study	7	Transporting another person or goods (to/from)
4	Purchase of daily goods, shopping trip (to/from)	8	Leisure activities (to/from)
		9	Vacation travel (to/from)
		10	Other trip, describe

Table 4. Example of a completed travel diary.

		Origin	Destination	Purpose
TRIP 1	From home to children’s day care	1	7	7
TRIP 2	From children’s day care to work	7	3	1
TRIP 3	To a meeting outside the office	3	5	2
TRIP 4	Back from the meeting	5	3	2
TRIP 5	From work to an eye doctor	3	9	5
TRIP 6	Home from the eye doctor	9	1	1
TRIP 7	From home to a petrol station	1	8	8
TRIP 8	From petrol station to a swimming pool	8	11	8
TRIP 9	Home from the swimming pool	11	1	8

3.4. Data logging

3.4.1. Hardware

A data logger is equipment used to collect data straight from a car, for example GPS data or data from an OBD-II interface. The logger device selected for data logging was the Driveco module manufactured by the company EC-Tools (**Figure 2**). DRIVECO Personal is a green driving advisor and automatic driving diary for smart phones. The device requires the participants to keep it plugged into the vehicle’s OBD-II interface.

Figure 2. Driveco data logger module. (EC-Tools 2011)

Interfaces and data transfer practices have been created to conveniently upload data from mobile devices to the central server. The data is processed at a central server operated by Emtele using scripts that parse and save log files in harmonized format to the central database. Logica operates, in collaboration with Mediamobile Nordic, a commercial traffic and weather information service called LATIS. In the TeleFOT project, this platform and its services were tailored to also record user GPS data along with usage statistics. Map matching is performed on the server as the service also includes features such as speed alert, where road segment speed limit information is used. The data collected by the LATIS database is transferred automatically to Emtele’s central server. The quality checks and user administration are, however, mostly performed with LATIS. (Koskinen et al. 2010.)

3.4.2. Software

In the Finnish LFOT used in this validation study, the nomadic device used during the trials is a Series 60 smart phone compliant with the Logica LATIS™ client. LATIS™ is a location-aware traffic information solution for drivers. It is based on Logica's Enterprise Mobility framework. Logica's location-aware traffic information solution is meant for organizations aiming to provide location-relevant and real-time information for drivers on the road. Traffic and road weather information are provided by Mediamobile Nordic. To achieve this and to comply with legislation, LATIS™ utilizes a built-in speech synthesizer to read aloud announcements of nearby incidents or other relevant info. An on-line map service is used to display the user's position and the exact location of the incident. In the full version of LATIS™, current speed and speed limit are also displayed. The current speed is read aloud if it exceeds the speed limit. As the information exchange in LATIS™ works both ways by nature, all users also produce advanced FCD information. Manual "one button" reporting of traffic incidents enables even a limited number of users to effectively provide traffic information. LATIS™ mobile phone application also works in the background, enabling simultaneous use of navigator software. (Pagle et al. 2009.)

The LATIS™ service (Figure 3) was integrated with the DRIVECO service provided by EC-Tools. DRIVECO Personal is a green driving advisor for smart phones and an automatic driving diary. DRIVECO collects information on fuel consumption from a separate module connected to the OBD-II vehicle interface. The module sends data via Bluetooth to a smart phone running DRIVECO software. Trip summaries are further collected from the smart phone to a web service for reporting and feedback (Driveco 2011). The device also allows monitoring and reporting of carbon dioxide emissions. (Pagle et al. 2009.) Driveco communicates with a cell phone with Bluetooth connection.

Figure 3. Latis screenshot. (Koskinen 2011)

Driveco collects, along with GPS-data, data straight from the vehicles' own sensors, for example rounds per minute, use of gas pedal and engine braking. This data is recorded by every modern passenger car independent of make and model. Driveco starts logging data as the engine is started, already collecting standing car data at zero rounds per minute. The trip can end for following reasons (Liedes 2011):

- The driver changes the purpose of the trip (from the software).
- The engine is shut down. In this case the logger will stay on standby for 2 minutes, and continues the same trip if the engine is started within 2 minutes.
- The cell phone moves outside the Bluetooth's reach, for example the driver exits the vehicle.
- The Bluetooth connection is lost.
- The cell phone's "end call" button is pressed.
- The user shuts down the device.

When brought within range, LATIS™ recognizes the active Driveco device and uses it as a signal to move from standby to active (map display). When Driveco shuts down, LATIS™ returns to standby. Data gathering works only when program is on map display mode. (Laakso, J 2010).

The TeleFOT project uses LimeSurvey, an open source survey tool for online questionnaires. Also paper questionnaires are formatted using LimeSurvey tools and printed out from the system. This approach ensures that all data can be conveniently saved to the central/local databases and can be linked with collected logger data. (Koskinen et al. 2010.)

3.5. Data

3.5.1. Travel diary data

This study was based on TD data collected during the before-phase of the Finnish LFOT when test participants had a limited set of services in use. These services included traffic information (TI), speed limit information (SI) and speed alert (SA). In addition, the driving diary feature of the green driving (GD) application was also in use. (Innamaa 2010.)

The diaries were filled in daily for a specific time span, in this case the first whole week of October 2010 (4-10.2010). If a participant forgot to start completing the TD on the given date, he/she was instructed to start filling it in as soon as possible and to continue for 7 consecutive days even though it would not be exactly the same week as for the other test participants. This kind of delay would not affect the schedule of the following TD data collection periods.

The validation study was based on 63 participants' trips reported in TDs. These 63 TDs contained altogether 1,831 trips.

3.5.2. Logger data

Logger data collected during the same time period as the TD were used in the validation study. In the Finnish LFOT, TeleFOT applications had an auto-start feature. However, it was dependent on having Bluetooth turned on in the mobile phone and the participant had to accept the application to actually start. A logger was included in the application and, consequently, it recorded the trip only if the application was turned on.

Six participants did not have any logged data from the time of their TDs. In addition, three participants had logged trips where they were passengers, against the guidelines. These trips (corresponding to trips reported to have travel mode 3 in TD) were 100% of all logged trips of these three participants. These participants were included in the validation, because if only logger data was used it could not have been known who the driver was. However, when validating trips made by car or van as driver, the trips made as passenger were excluded, leaving the amount of logger data journeys as 1,045 journeys.

3.5.3. Combined data

TD trips and logged trips were matched for the 54 participants (six participants not having any logger data and three who had only logged journeys as passenger were excluded) when times and length of trips could be reasonably matched. In the combination of two data sets, trip starting time in the logger data had to differ by a maximum of 10 minutes, or be included in the TD trip time frame. Likewise trip ending time in the logger data had to be within the TD trip time frame or to be a maximum of 10 minutes more. Crucial in this matching was trips represented in the TDs; matching could be done only if there was no other trip within a 20 minute time frame that the logger data trip could be matched with. This was done because test participants' accuracy in reporting TD trips was expected to vary to some extent.

Logger data had fragmented trips, for example multiple logger data entries fitting between the starting and ending time of a single TD trip. For comparing data and logger data calculations, every fragmented trip was handled as one trip but separately from trips with a single corresponding trip in the logger data. To neutralize the biasing effect these fragment clusters might have had in data analysis, clusters were added up to have only one length, starting time and ending time.

A combined data set was made where matching trips were inserted as single entries. Trips with no counterpart in both data sets were included in the combined data as incomplete entries. The combined data included 1,970 lines of data (TD trips, logged trips and logger trip fragments) totalling 1,831 trips. The difference was due to the fragmentation.

3.6. Test participants

All 63 test participants whose data were used in this study returned their demographic survey. For a general understanding of the group make-up, basic demographics are shown. A clear majority (82.5%) of the participants in this study were male, female drivers being under-represented. The results will thus not give a good picture of a Finnish driver, but more of a Finnish male driver. However, the results probably give a good picture of most potential customers of nomadic services.

Participants' year of birth ranged from 1943 to 1989 (Figure 4), making the oldest participant during the first TD 67 years old and the youngest 21 years old. With 5-year intervals most of the test participants were born between 1970 and 1979. Exactly one out of two (50.0%) test participants use a visual aid (eyeglasses or contact lenses) while driving.

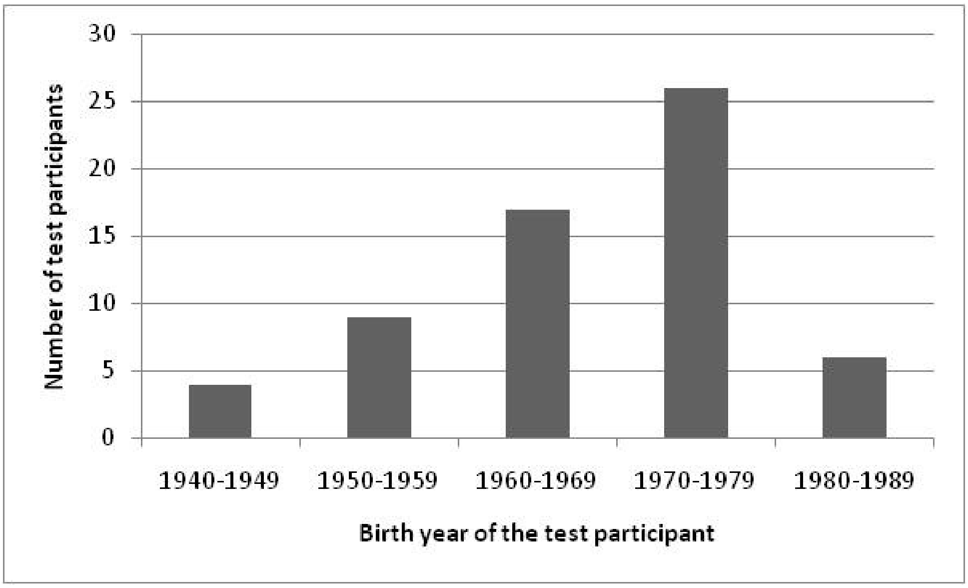

Figure 4. Birth year of test participants.

The majority (58.7%) of test participants had had a driving license for 11-25 years (Figure 5). The participant who had driven the longest had had a license for 49 years, whereas the shortest driving time was 3 years.

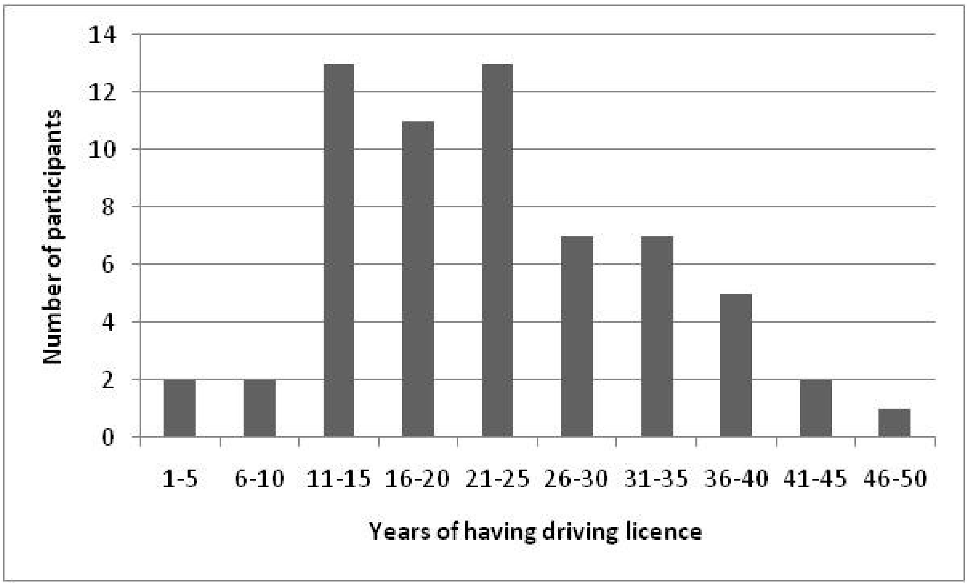

Figure 5. Participant's years of holding a driving licence.

The test participants in this study had, according their years of having had a driving licence, very different driving experience and thus possibly different driving styles. The diversity of test participants' age and driving experience provides an opportunity to study the effect of offered services on different age and experience groups.

The two most popular models of primary car among the test participants were Toyota and Volkswagen (both 14.3%, or nine out of 63 cars). The most common model year was 2008 (Figure 6). Although some brands are more popular than others, there is variety in both brands and models. This variety lessens the risk of systematic error based on the car used.

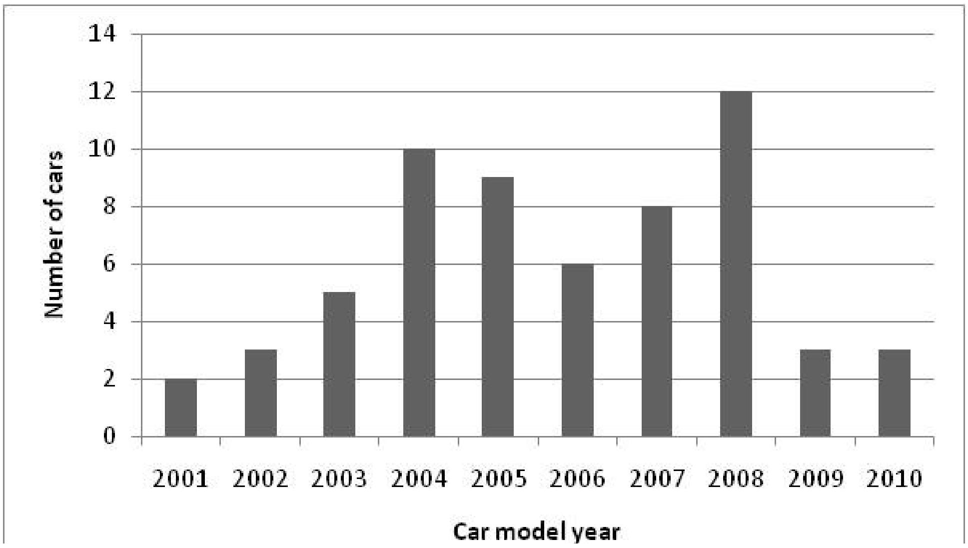

Figure 6. Participant car model years.

3.7. Study site

The functions provided by TeleFOT can be used across the entire Finnish road network. The total length of the network is 454,000 km, including 78,000 km of public roads, 26,000 km of streets and 350,000 km of other roads including private roads, forest truck roads etc.

The total amount of kilometres travelled in Finland was 53 billion in 2008, of which 67% (35.6 billion km) were on public roads. 76% percent of the trips were made as the driver or passenger of a passenger car, 15% by public transport and 5% on foot or by bicycle. Personal transport (total amount of km) increased by 62% in the period 1980–2008, personal car transport by 82%. (Tiehallinto, 2009.)

All road types are included in TeleFOT in order to assess the functions in different environments. The use of road types is determined by the participants as the FOT is of natural driving. (Pagle et al. 2009.)

4. VALIDATION RESULTS

4.1. Trips reported in the travel diary

4.1.1. Accuracy of form filling

In the TD there were 12 factors to report about each trip. Seven factors, namely origin, destination, start time, end time, trip length, mode of travel and purpose, had to be answered in order for the TD to be fully filled for analysis if no functions were used and nothing unusual happened. Mode of travel was used in the assessment of accuracy of filling instead of primary mode of travel, as one participant had filled in only the mode, leaving the primary mode empty.

Percentage of fully filled entries in the TD was calculated from all the trips in each of the 63 participants' TD (Figure 7). On average, the participants answered all seven factors in 96.3% of their TD entries. Diligent completion of the TD was common, with 85.7% of the test participants having answered specific factors in 90-100% of their TD entries and as many as 95.2% in over 80% of their TD trips. Only three out of 63 participants had less than 80% of their TDs fully filled in, the minimum being 47.6%.

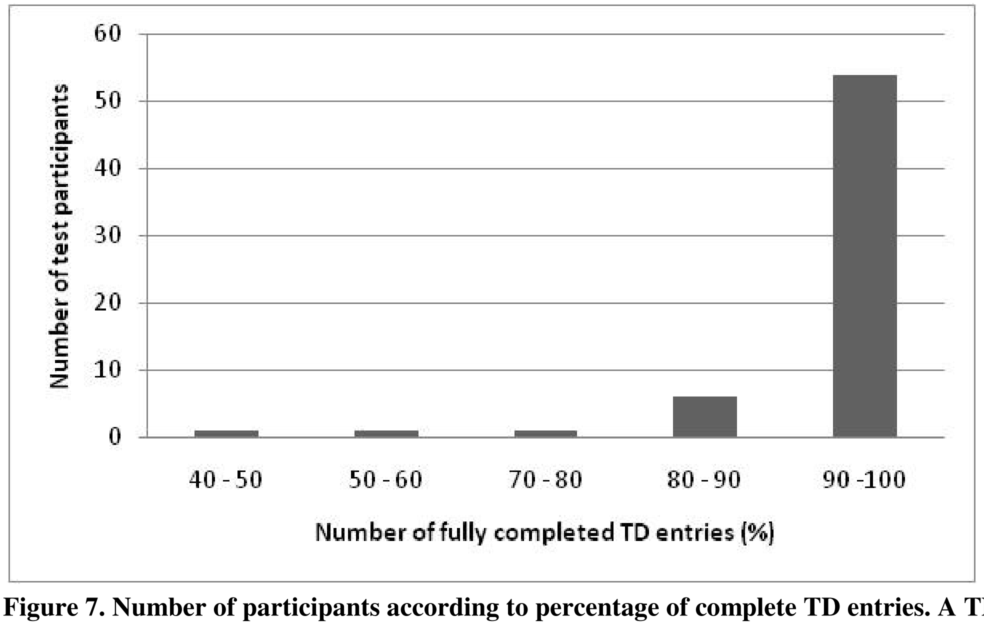

Figure 7. Number of participants according to percentage of complete TD entries. A TD entry was considered complete if the origin, destination, start time, end time, trip length, mode of travel and purpose were reported.

The generally high level of completion portrays TD as a well accepted method among participants, but leaves room to ponder whether this diligence will continue as the study progresses. The answer rate of the first TD collection was 63% (63 filled in and returned TDs vs. 100 requests sent). As time progresses test participants may become forgetful and negligent during TD answering week. TD collections are located 3 to 4 months apart, so even when the novelty of the study wears off, the task might not be seen too laborious. Boredom with the study may occur, and this may reduce the percentage of answers, but quite possibly the change will not be dramatic.

With two exceptions, factors were marked down with a minimum of 99% accuracy. The peak factors were “origin” and “destination” answered within 99.9% of TDs; the least marked were “purpose” and “mode of travel” that were answered in 98.6% and 98.7% of TD entries, respectively.

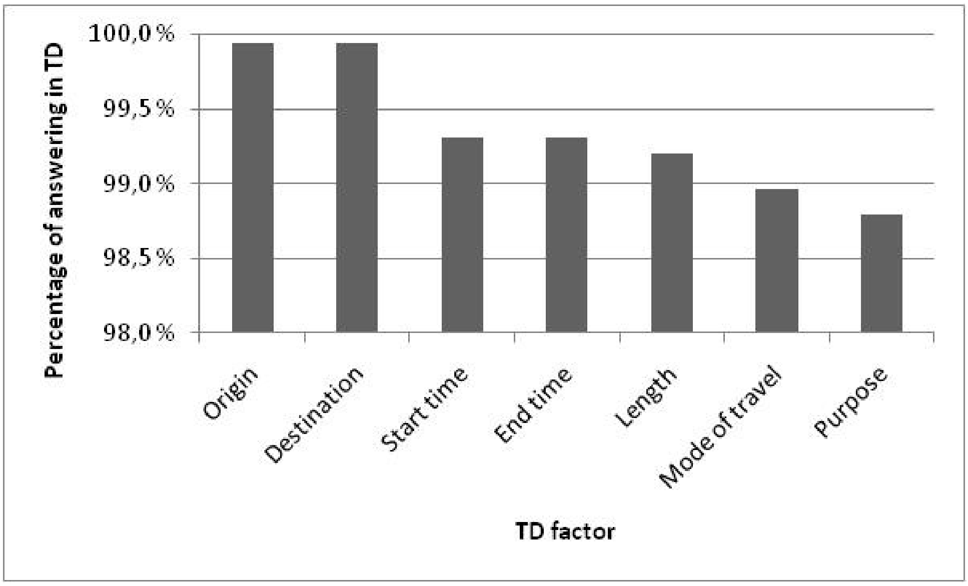

Figure 8. Diligence of filling in the seven factors in the TD required for the TD to be fully answered.

Origin and destination are the factors easiest to remember and fill out afterwards, as they most often are from a predefined list. It is hard to know why the purpose was not filled in more, as the participants would probably remember their trip’s purpose at least from their trip destination. It could be that in some of the unanswered cases, the trip purpose was felt to be ambiguous and thus left out.

4.1.2. Mode of travel

In the TD, 18 different modes of travel were specified (Table 2). The most popular mode of travel was driving a passenger car or van, as 68.4% of test participants had driven a car in over 80% of all their TD trips. The large amount of trips driven by car is also a good sign, as it means that a large proportion of test participants' trips are potentially possible to log. Among the remaining 22.8% of trips, three modes of travel were up in popularity: passenger in a car or van in 10.2% of all TD trips, pedestrian in 4.5% and bicycle in 2.0% of all TD trips (Figure 9). In nine categories, there were less than 1% of all TD trips in each (local bus, tram, train, taxi, airplane, motorcycle, boat, lorry, and tractor) whereas in five categories there was no recorded action (long distance coach, metro, moped, skidoo, and other mode of travel).

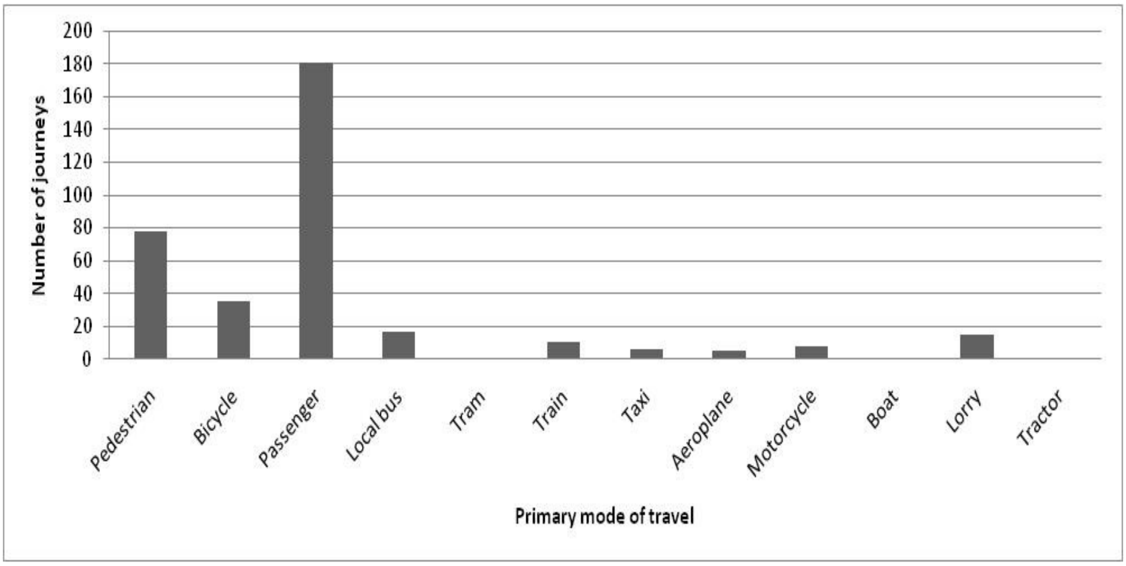

Figure 9. Trips according to primary mode of travel, excluding the mode driver of passenger car or van.

In the coming TDs in Finland it will be interesting to see whether the dominance of driving gives way to other modes of travel, especially in summer. The first TDs were completed in October, when the weather was fickle, cool and possibly rainy and the motivation needed to use other modes than a private car was low. As the next TDs are completed in February, May and October 2011, there may be changes due different weather conditions. Another factor affecting the popularity of the private car is the geography of Finland as a sparsely populated country with long distances. Test participants can live outside the reach of public transport, stripping them of options to choose from.

Test participants could report the use of multiple modes of travel during one trip, but were instructed to mark as the primary mode of travel that which was used for the longest distance. 99.0% of all TD entries had at least one mode of travel and primary mode of travel written down. Two or more modes used were reported on 4.7% of trips, whereas three or more were reported in 2.8% and four in 0.2% of trips.

Only 17.5% of test participants made multi-modal trips. Among the test participants the popularity of multiple modes varied a lot, from a maximum of 88.5% of participant's trips to a minimum of 2.4%. With trips that had more than one mode of travel, the most common primary mode of travel was as a passenger in a passenger car or van (41.5%) followed by driver in a passenger car or van (29.3%) (Figure 10). The most common secondary mode used was pedestrian in 82.7% of journeys, implying longer walks to the car and back, or the test participant forgetting that he/she was not meant to mark down short walking trips.

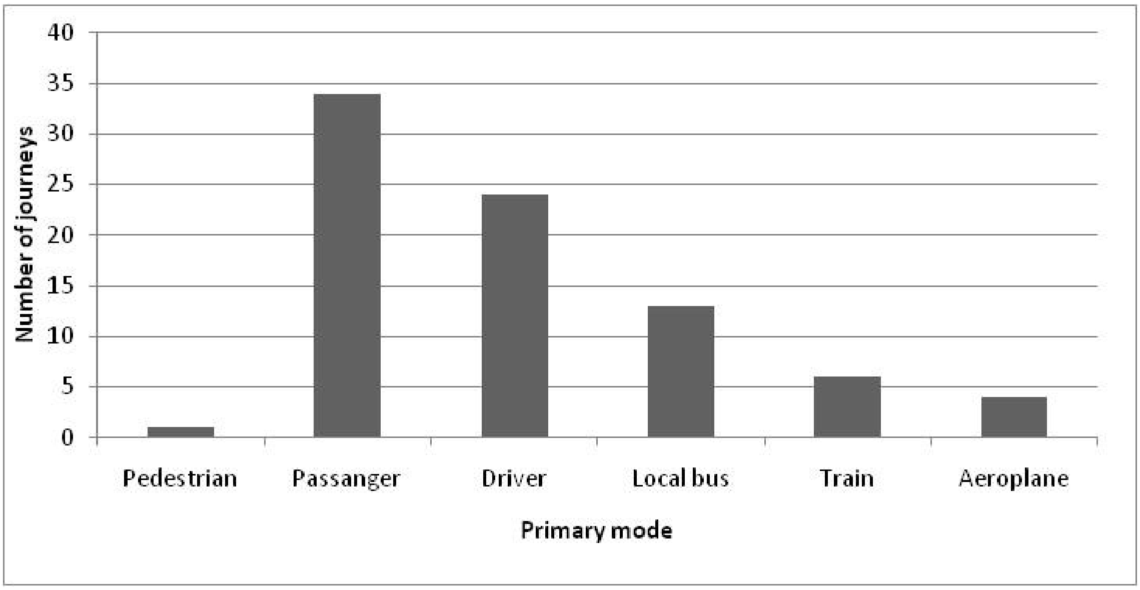

Figure 10. Primary mode of travel in multiple travel mode trips.

The small number of trips with more than one mode of travel may also be explained by geographical and infrastructural factors. Obviously only a few of the test participants live in an area with many modes of travel to choose from, as nine modes of travel had less than 1% of all TD trips in each and in five modes there were none. Some of the less popular modes can be explained by geographical factors, because local bus networks are extensive only in the biggest cities, and tram and metro networks only exist in the capital, Helsinki. Avoiding motorcycle travel goes with the season, as October is not a favourable time of year for this activity.

4.1.3. Purpose of trip

In the TDs ten different purposes of travel were defined for the test participant to choose from (**Table 3**). The purpose was reported for 1,718 trips, with four cases where the purpose had been mistakenly marked as 11. These four cases were excluded. As the primary mode also had to be included in the TD for analysis of the reported purposes, the number of trips in the analysis of purpose of trip decreased to 1,699. In view of the predominance of driving a passenger car or van as mode of travel, the results were separated into two parts: one excluding drivers, and one including only them. The calculations were based on 1,352 trips made as the driver of a passenger car or van and 347 trips in other modes.

Modes of travel excluding that of driver of a passenger car or van were divided into purposes as shown in Figure 11. Here the passenger of a car or van was the most popular mode, with 51.0% of all trips exluding driving a car or van, and leisure (36.2%) and commuting (27.7%) being the most common purposes of trips made with this mode. The pedestrian mode comprised 22.5% of the trips, having leisure as the most common purpose of travel (85.9% of pedestrian trips). Together these two modes formed clear the majority of trips (73.5%). It is interesting that bicycle trips had only two purposes: 69.7% for commuting and the remaining 30.3% for leisure.

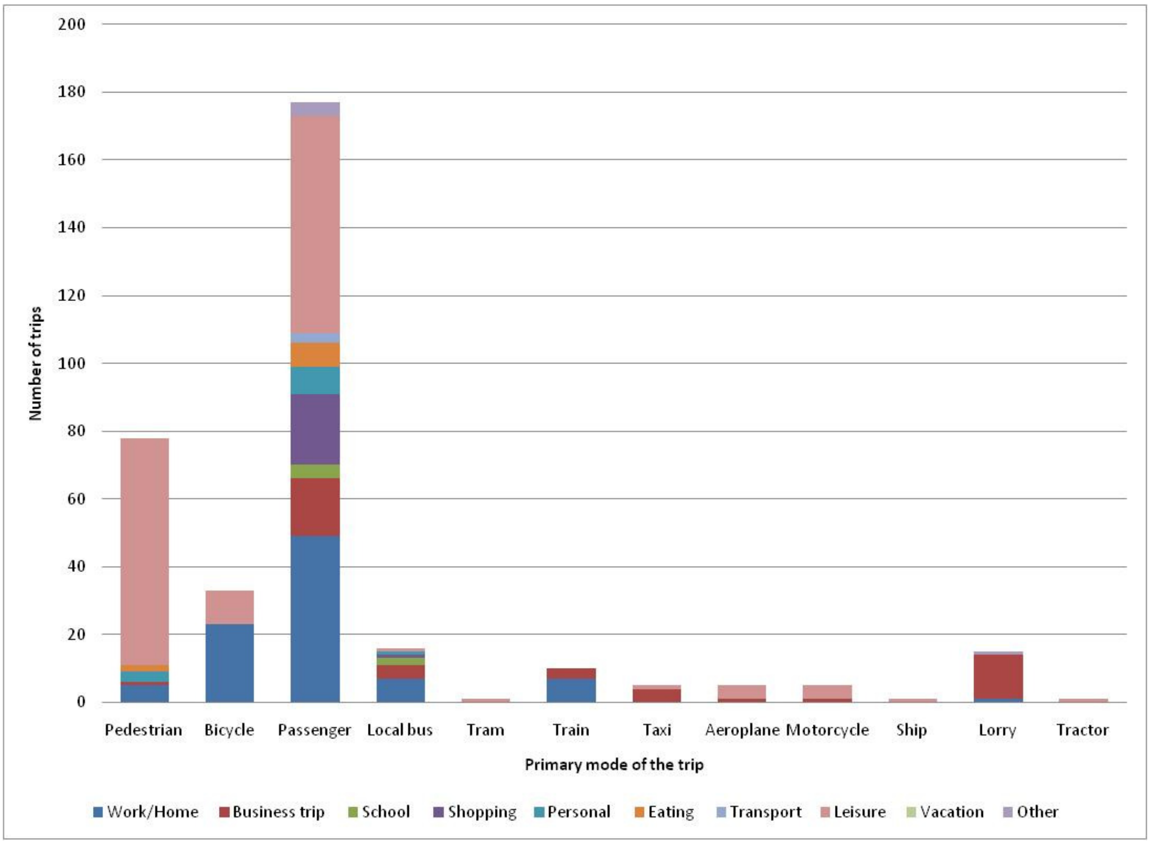

Figure 11. Primary modes of travel divided by purpose (excluding the mode of driver of a passenger car or van).

Of the 10 trip purposes, leisure (41.2%) was the most common excluding those made as the driver of a passenger car or van (Figure 12). The two most common modes used were pedestrian (43.5% of leisure trips with a mode other than driver of a passenger car or van) and passenger of a car or van (41.6%). Leisure activities compose a great share of test participants' reason to move. Not all destinations are far away, as many of the destinations were reached on foot.

The second and third most common trip purposes were commuting (24.6%) and business trip (12.7%). For commuting, the two most commonly used modes were passenger of a car or van (53.2% of commuting trips made with a mode other than driver of a passenger car or van) and bicycling (25.0%). For business trips, the two most commonly used modes were passenger of a car or van (38.6% of business trips made with a mode other than driver of a passenger car or van) and lorry (29.5%). The high share of business trips by lorries can be attributed to their being used to transport goods, causing a work day to contain many business trips. It is probable that at least one of the test participants drives a lorry as their profession.

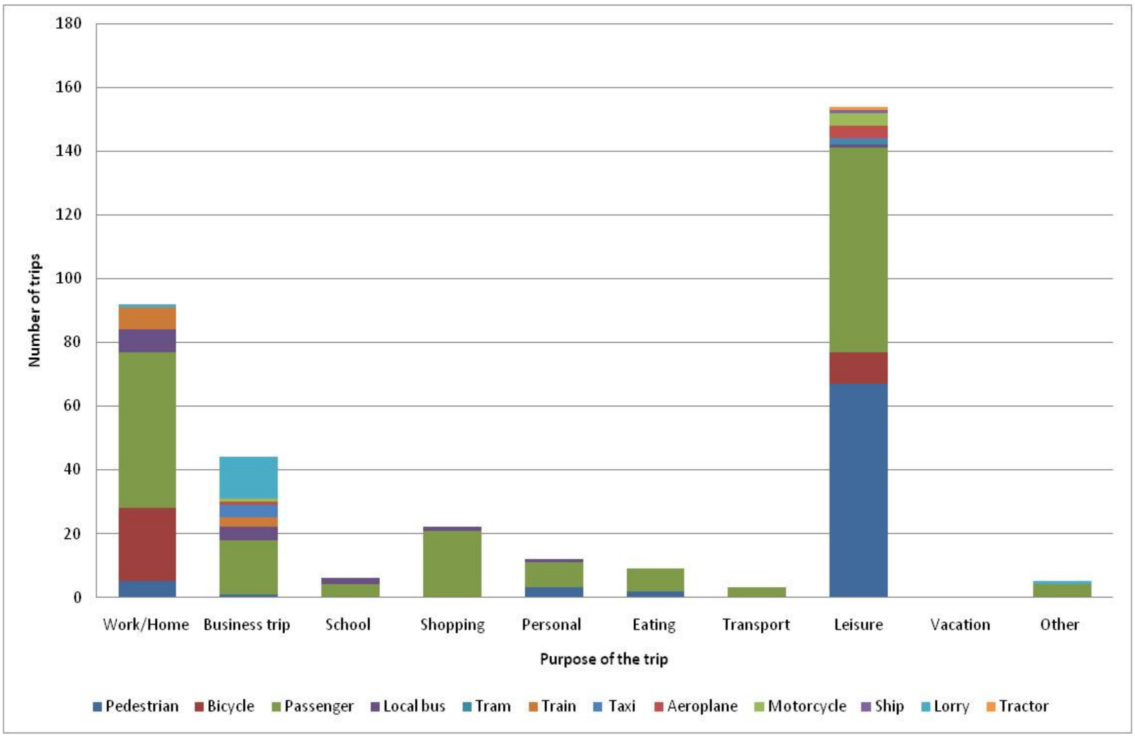

Figure 12. Trip purposes divided by trip's primary mode of travel, excluding primary mode of driver of passenger car or van.

When moving to the travel mode as driver of a passenger car or van, the three most popular purposes of trips were commuting (32.2% of trips made as driver), leisure (20.0%) and shopping (16.5%, Figure 13). Unlike the other modes of travel, driver of a passenger car or van was a mode used for every purpose of travel.

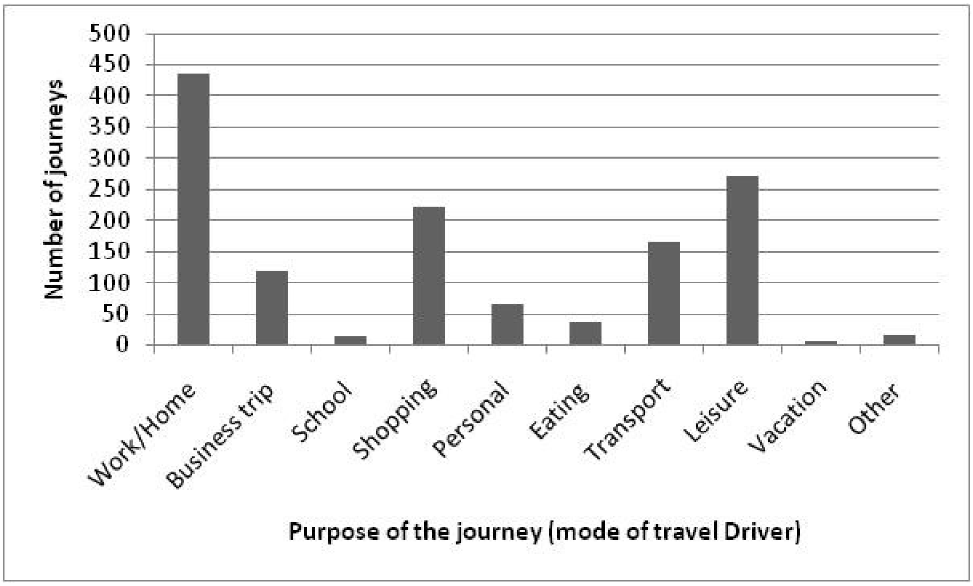

Figure 13. Trips made as the driver of a passenger car or van according to purpose.

4.1.4. Use of functions

The first week of filling in the TDs was made during the before phase of the FOT. Then only traffic information and the driving diary feature of the green driving application were activated. In addition, contrary to the original plan, a speed alert service was available to all test participants.

The use of offered services during the trip was reported in 30.0% of trips (Figure 14), and in 36.0% of trips driven by a passenger can or van. 24.7% of the reported trips had other than only traffic information service in use. Before the trip, services were used in 7.2% of the reported trips, and afterwards only in 3.2% of the reported trips. Use of services was not confined to the use of a private car as the driver, as instructed, but also occured during trips made with a tractor or bicycle in addition to trips made as a passenger.

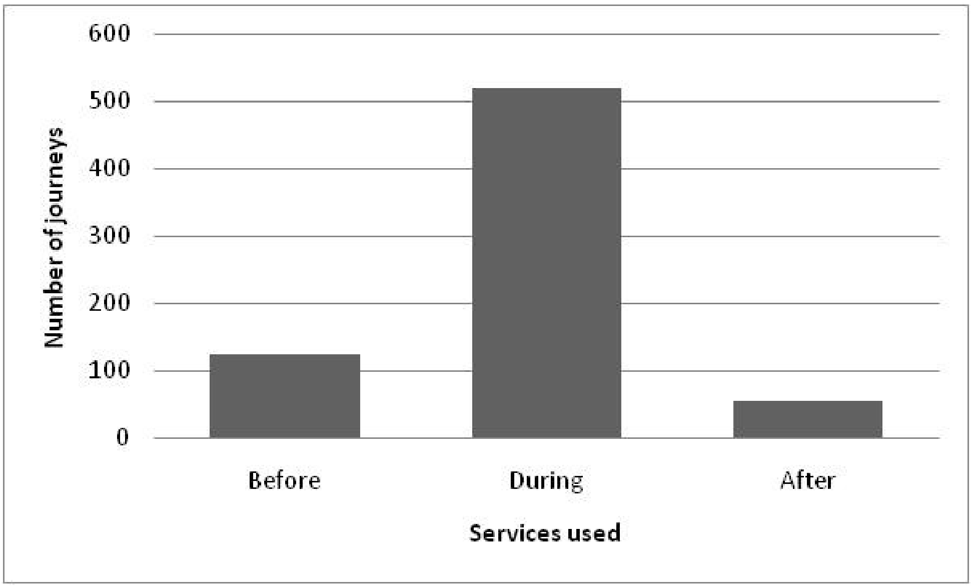

Figure 14. Services used in the trip.

Test participants were clearly interested in using the offered services. This is only natural as they wanted to participate in a study where different services were being tested, some actually refusing to take part if placed in a control group with only the most basic services. They probably gave an overly positive picture of the average Finnish driver's willingness to use services.

During the actual FOT with all the services available, the use of services is likely to rise. After an adaptation period, the participants form their own opinion of the services, from which point their attitude may deviate in two directions, either towards negligence if several services feeding information are felt to be irritating, or getting used to the stimulus and developing a habit of reacting to the services, or a combination of both attitudes. It will be interesting to see how the test participants' attitudes develop, as this will give a strong indication of the level of acceptance and allowance for guidance and disturbance during trips.

4.1.5. Use of options "other" and "unusual"

In filling out the TD, the test participant was offered a number of predefined locations, purposes and modes of travel. If none of the options offered in the TD suited the trip, test participants had the possibility to describe the trip verbally. As the readily available option lists were fairly comprehensive, this option was seldom used. Destination was described verbally for 4.0% of all TD trips, purpose for 2.4% of TD trips and origin for 1.9% of TD trips.

19.0% of test participants reported something unusual in their TDs, resulting in more information in 7.3% of all TD trips. Here the most common reason (43.8% of all unusual trips, which is a mere 2.4% of all TD trips driven by car) was participants' problems with DRIVECO's performance (the application did not work or froze). Also mentioned were problems with incorrectly logged logger data (19.2% of unusual trips), where the logged journey had fractured, the journey length was incorrect or the point of origin or destination was wrong. In 17.8% of unusuals (1.0% of all the TD journeys), participants reported that the TD trip was driven with other than their own car. In 6.8% of trips marked unusual, the reason was traffic conditions like slippery road, crash or traffic congestion. The remaining 12.3% of unusual trips consisted of several trips test participants do not make often, like taking the car to be washed or an elk hunt.

To sum up the chapter, the 63% of test participants who filled the TD were very diligent, answering 96.3% of their TDs in all seven required factors. From the TDs it was discovered that driving a passenger car or van was the most popular mode of travel, comprising 77.2% of all journeys, and the most popular purpose of journey was commuting, with 32.2% of driven trips. Use of offered services was reported in 30.0% of all trips, and in 36.0% of trips made by a passenger can or van.

4.2. Trips recorded in both the travel diary and logger data

4.2.1. Number of trips

The test participants were advised to log the trip (in practice, activate functions) only if they were driving. However, out of 181 trips where the participant had marked in the TD that they had travelled as a car passenger, 50 trips also had corresponding logger data. This resulted in 4.6% of logger data representing the driving behaviour of other people than the selected test participants. Consequently, these trips logged as passenger were not counted in the total number of trips with both data. If these trips logged as passenger were included, 1,003 trips (57.5% of all TD trips) would have both data instead of 930 trips (55.9% of all TD data). Also six participants missed logger data completely. The results show that TDs and data loggers do not yet work together well. Some participants also had problems in data logging or did not use loggers. The analysis in this chapter was conducted with 54 test participants having correctly logged data. Calculated from all TD data and logged trips, 55.9% of test participants' trips can be found from both TD and logger data. Fragmented trips were counted here as one trip per set of fragments.

38.5% of trips made by passenger car or van as the driver missed either TD data or logger data. More specifically, 40.7% of TD trips that should also have been logged were missing the corresponding logger data and 8.2% of logged trips were missing the corresponding TD entry. The reason for missing trips in the logger data is the lack of fully automatic logging and consequently participants not turning the application on. In addition, some trips reported to have been driven were made using another vehicle than the logged car. Therefore 100% correspondence cannot be expected. Missing TD trips are consequent to test participants forgetting to report them. The gathered data was unevenly collected, as 29.6% of test participants had gathered over 25% of other data, 25.9% had more TD data and 3.7% more logger data.

The amount of TD and logger data pairs was divided by the total amount of trips per person. Counted with all 54 test participants included in this validation, 75.9% of them had both TD and logger data in 50% or more of their trips (Figure 15). When setting the limit on at least 80% of trips the proportion of test participants was 35.2%, and 16.7% of participants had at least 90% of their trips in both sets of data.

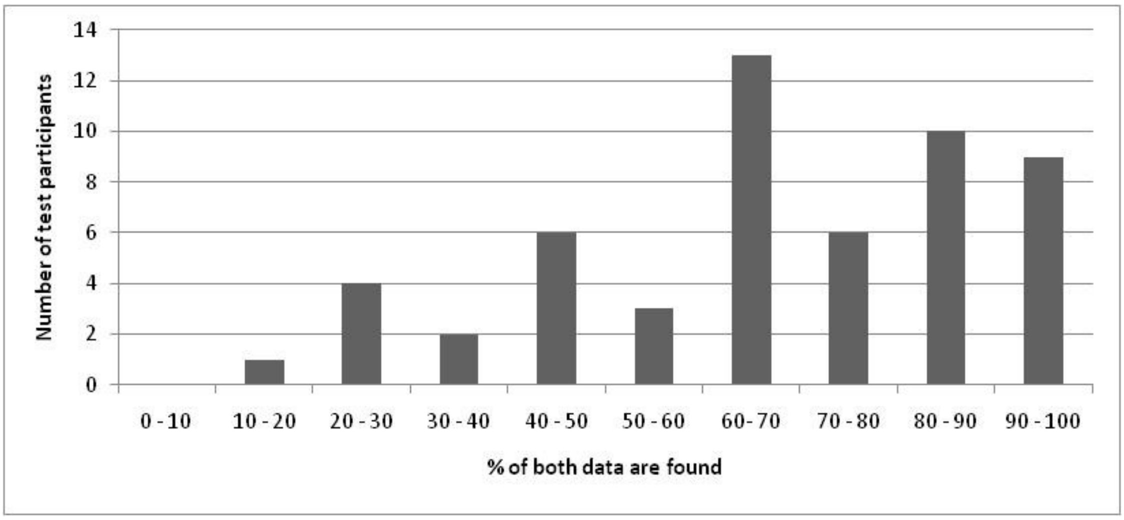

Figure 15. Proportion of car trips for which both data were recorded, per test participant.

As only 35.2% of test participants had both data in at least 80% of their trips, the result clearly indicated that other data was overrepresented in the participant's data set. From the 54 test participants, 29.6% had over 25% more of the other data: 25.9% had more TD data and 3.7% logger data (Figure 16).

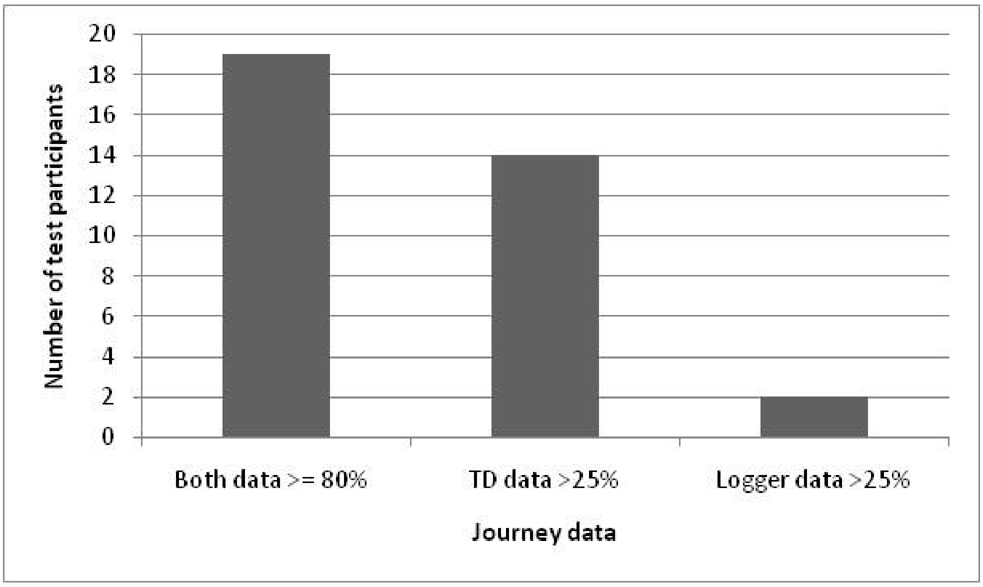

Figure 16. Number of participants having at least 80% of trips in both data sets and number of participants whose data stressed on TD or logger data by over 25%.

When the limit of stress was lowered to 50% of other data, 11.1% of participants had more TD data but none had 50% more logger data. The total amount of data is very uneven for some of the participants. The number of participants having >25% of TD data clearly suggests that they had some kind of problem with data logging and would need help to log correctly. The participants having >25% of logger data are more peculiar, suggesting that they were forgetful or not that interested in completing their TDs. Either way, the importance of filling in a TD in a given week should probably be stressed a bit more to get a more accurate picture of these participants.

Only four of the 54 test participants (7.4%) had a corresponding logged trip for all of their TD trips, whereas one third (33.3%) had a corresponding TD entry for every logged trip. 29.6% of test participants missed only 0-10% of logger data and exactly half (50.0%) missed a maximum of 20% of corresponding logger data trips. The results prove that participants had the skill to use data loggers quite well, but it was either forgotten or chosen not to be used by many participants on many trips.

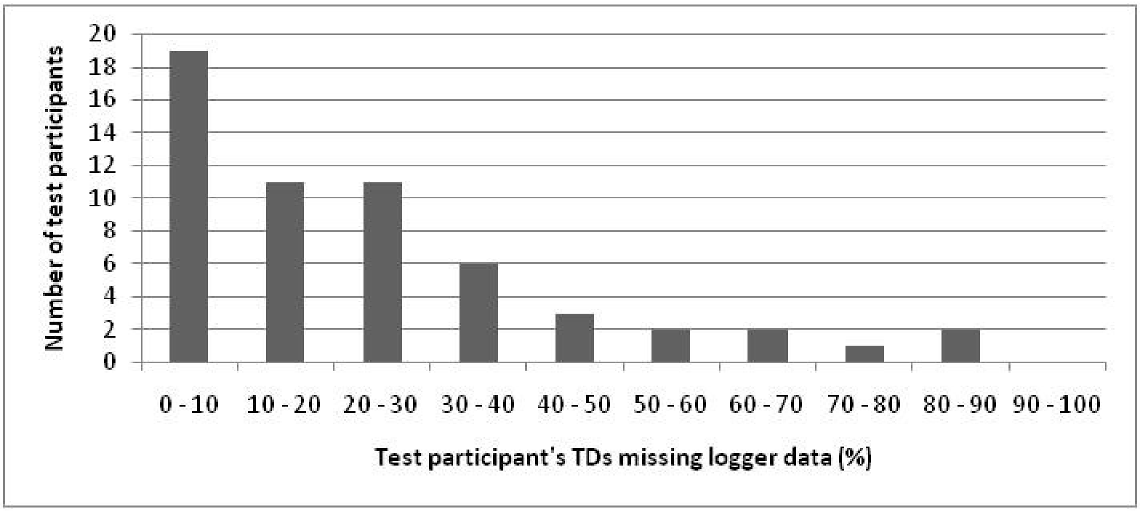

Figure 17. TD missing corresponding logger data in percent from test participants' TD trips.

The most common purpose of trips missing logging data was commuting (31.7%). The reason for routinely logging what seemed like similar, repeated trips might have been lost on test participants, even though the effect of services can be most clearly seen in the changes in driving a repeated trip. The second purpose was leisure trips with 23.4% of all trips missing logging data. These results were in accordance with the popularity of purposes per all TD trips, where these two purposes comprise 52.2% of all purposes (Figure 13).

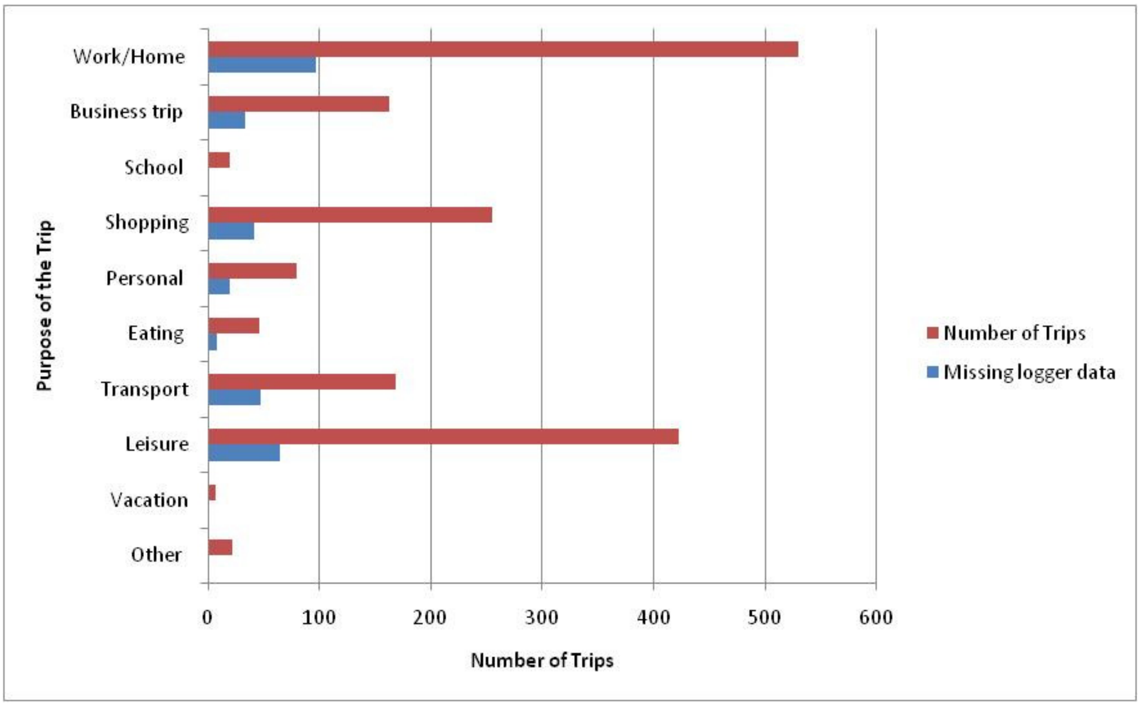

Figure 18. Number of TD trips missing logger data, according to trip purpose.

However, commuting and leisure purposes did have logger data, as corresponding logged trips and TD trips were found in 70.0% of commuting trips and 65.9% of leisure trips reported in the TD. When studied by proportion of missing logger data and not by mere amount, transport as a purpose missed the most logger data on most of its trips (28.0% of all transport trips), followed by personal business with 23.8% trips missing logger data, with leisure and commuting coming in fourth and sixth place respectively. Based on the results, participants driving transportation and personal business trips are more prone to leave the journey unlogged, but a higher TD-logger data ratio would be achieved if commuting and leisure trips were logged more duteously as their sheer number exceeds the others. This could be achieved for example if participants felt that they benefit most from the systems available for those trips, for example in congested commuting conditions.

Observed from the logger data point of view, test participants reported their driven trips in the TD quite meticulously. Two thirds (66.6%) of test participants had a corresponding TD trip entry for their logged trips (Figure 19), and 55.6% of participants had a TD entry in 90-100% of their logged journeys. A corresponding TD entry was found for at least 30% of logged trips, showing that every participant who returned the TD had at least tried to mark down most of their trips.

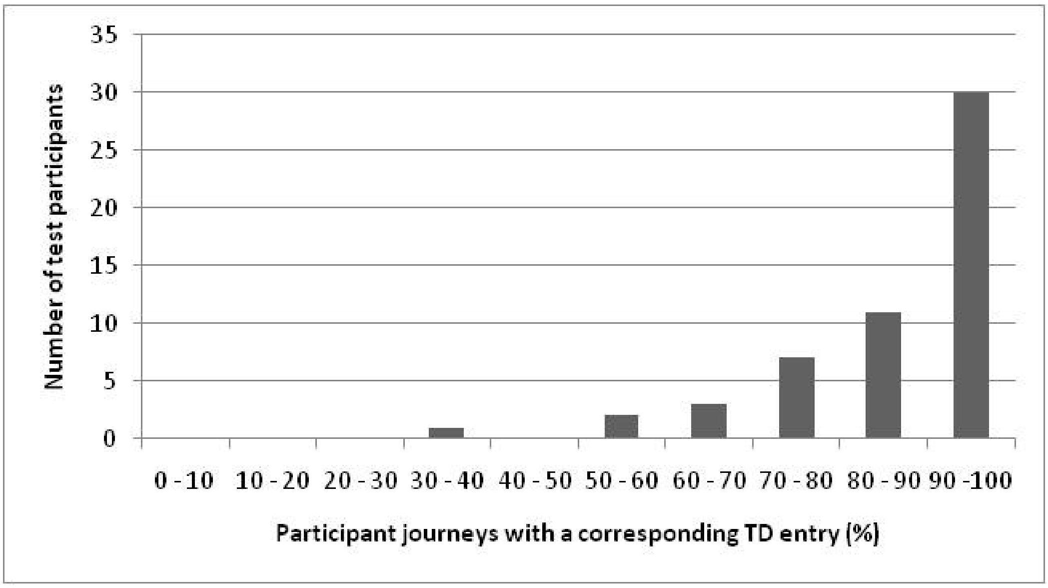

Figure 19. Participants' logged trips with corresponding TD trips, percentage from the participant's trips.

70.3% of participants missed a corresponding TD trip in less than 10% of their logged trips (Figure 20). None of the participants missed logger data for over 50% of the corresponding TD trips.

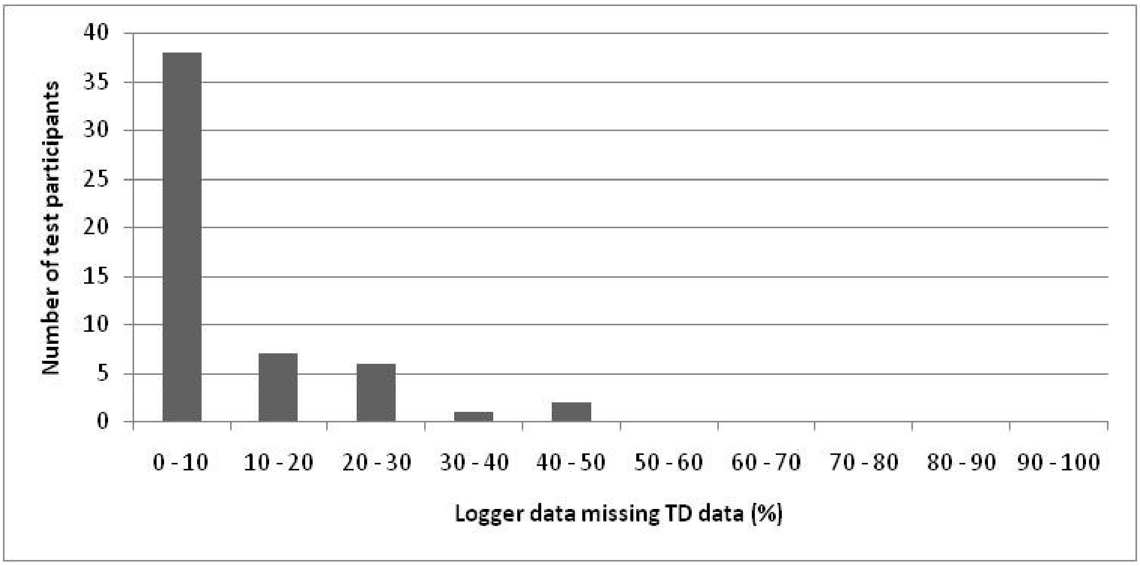

Figure 20. Test participants' logged trip missing corresponding TD trip in percentages.

The length of the logged trip had no effect on whether the trip was reported in the TD or not. The shortest trip that was not marked down in the TD was 7 metres, and the longest 39.7 kilometres (Figure 21). However, it must be noted that according to the instructions very short vehicular trips (for example moving a car from one place to another very close by, not an actual trip) were not meant to be included in the TD. 14.9% of trips missing a corresponding TD entry were shorter than 200 m and 95.4% of logged trips missing a corresponding TD entry had length less than 20 km. Short trips should not be considered as trips outside the TD, but as cases where the trip should be filtered from the logger data. Here trips of less than 200 m might also be one reason for over-representation of logged trips with some test participants. They probably had data loggers activated also when moving their car, causing "ghost trips" that could be eliminated from the study, as the main point is to study the mobility of test participants, not how many times their car is moved.

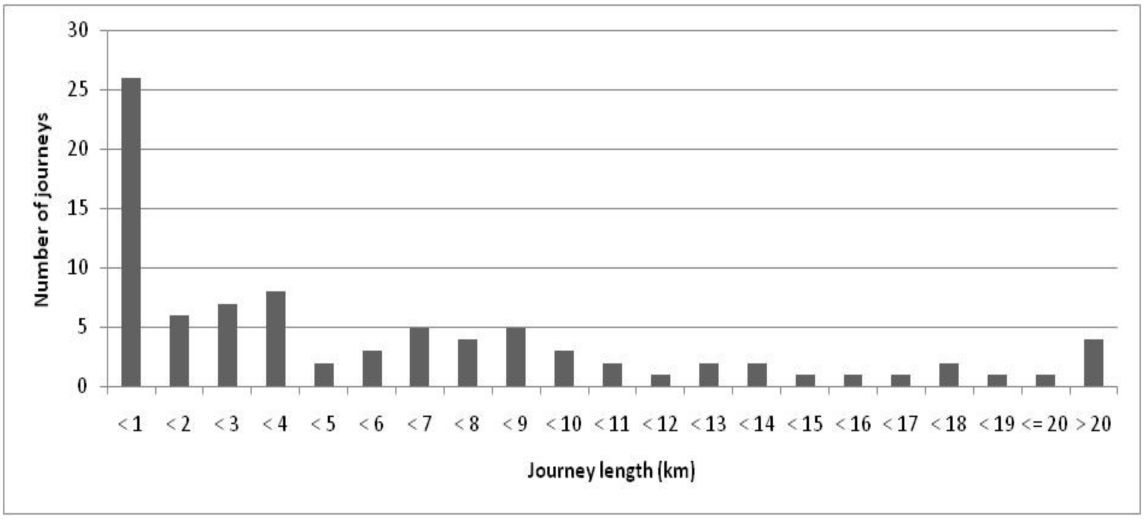

Figure 21. Length of logged trips missing corresponding TD entry.

Logger trips without TD data were heavily stressed on trips with length less than 1 km (29.9% of trips). These short trips can be "ghost trips" as explained above or short trips simply forgotten to be added to the TD after the trip.

4.2.2. Trip length correspondence

Trip length was recorded both in TD data and logger data: in the TD it was reported by test participants and in the logger data counted by data logger. Trip length correspondence was studied from the trips where the TD gave the primary mode as driver of a passenger car or van, excluding five trips where the TD missed the length of the trip.

Trip lengths were considered equal if the logged trip length differed by at most 10% from the TD trip length. Consequently, 76.9% of trips had equal length in both data sets. Within this margin of error, only three journeys were exactly of equal length whereas 49.1% of equal length trip pairs had a longer TD trip and 50.9% a longer logged trip, showing that test participants marked their trip according to their own estimation or found it from a source that gave a different result from the data logger. Among the trips with both data, in 5.3% of TD trips having corresponding logger data this data was fragmented.

With pairs of trips of (more than 10%) different length, the TD trip was longer in 75.8% of cases (in other words in 17.5% of all trip pairs found from both data). The reasons could be that participants had made part of the trip with another vehicle, overestimated their trip length when marking it down in the TD, or the data logger logged only part of the trip. Logged trips were, for one, longer in 5.5% of all the trips found from both data. The reasons for longer logged trips are e.g. underestimated TD trips and a logger that connected two different TD trips as the same.

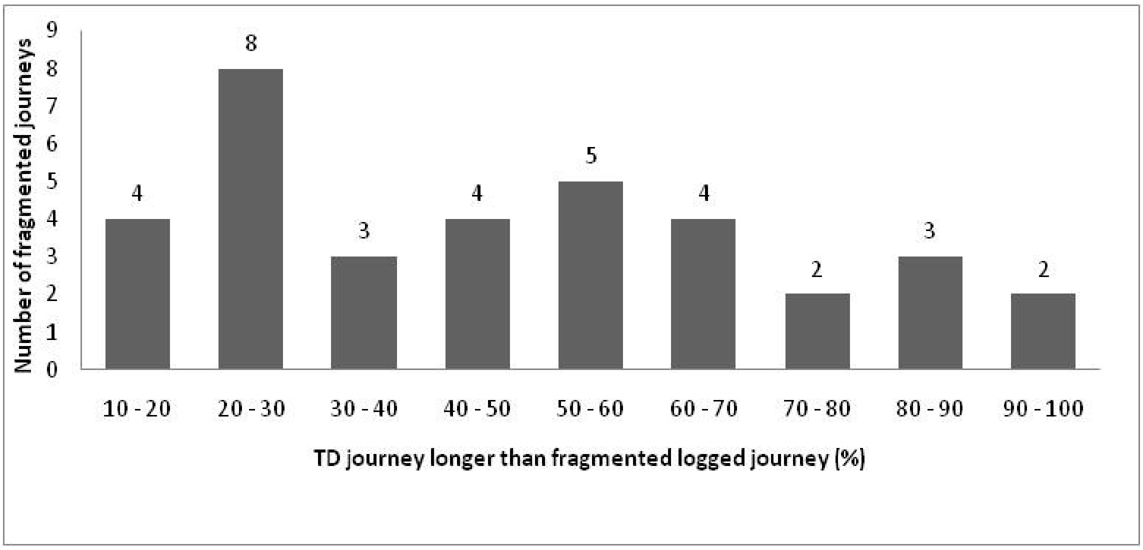

Figure 22. TD trip longer than fragmented logged trip.

4.2.3. Trip time correspondence

Trip starting time matched in 91.9% of trips found both in the TD and logger data (Figure 23). The time was considered to match if the difference was at most 5 minutes from the TD starting time. Trip ending times matched only in 83.0% of trips. Inside the margin of error, 33.5% of TD journeys had a longer duration whereas in 17.1% of trips the logged trip was longer. Trip starting time was earlier in the TD for 23.1% of trips and in logged trips for 25.4% of trips. Trip ending time was earlier in 19.0% of TD trips and in 25.5% of logged trips. In time correspondence analysis, four journeys that missed either trip starting time, ending time or duration in the TD were excluded.

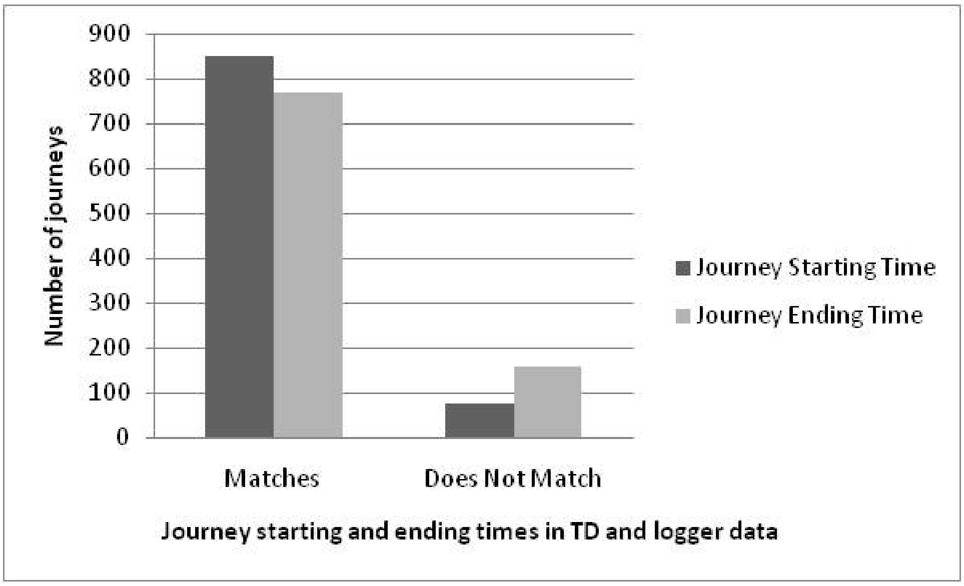

Figure 23. Matching trip starting and ending times in TD and logger data. The accepted error margin was 5 minutes from the TD start and ending time.

The test participants had a starting time correspondence of 90-100% in on average 12.3% of trips and of over 80% in 28.1% of trips (Figure 24). With starting times, data correspondence was stressed in over 50% of trips (61.4% of test participants). Only 7.0% of participants had 0-10% of starting time correspondence in the data.

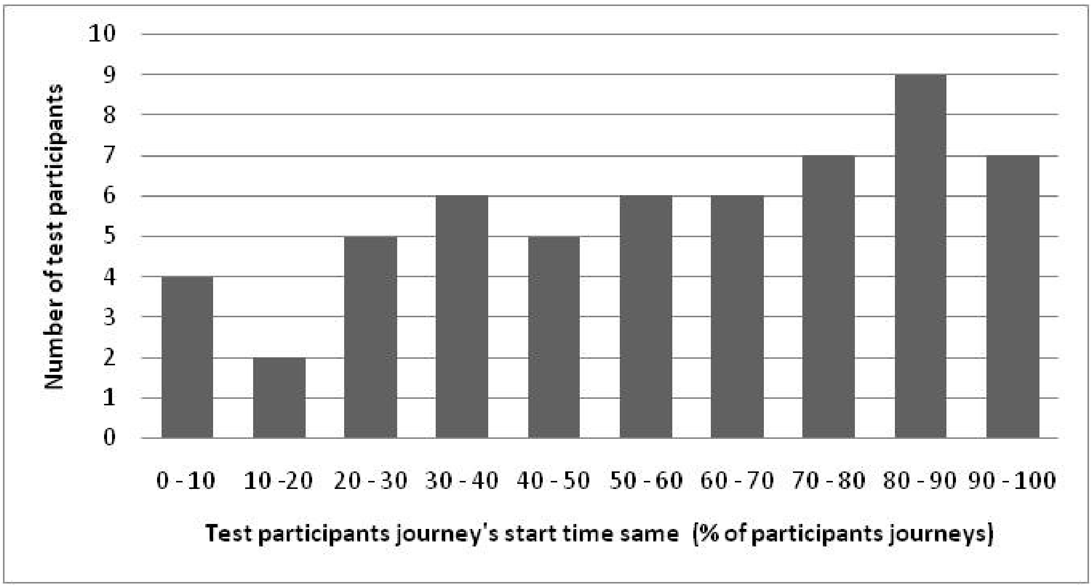

Figure 24. Matching trip starting time in TD and logger data, per person. The accepted error margin was 5 minutes from TD start time.

The results indicate a large personal difference in test participants' diligence and accuracy in filling in the TD and using the logger device, as the results are spread through every decimal.

With trip ending times, data collection methods did not work together as well as with starting times. Only 54.5% of test participants, compared to 61.4% for starting time, had trip ending times matching in over 50% of their trips (Figure 25). Only 7.0% of the participants had corresponding data in over 90% of trips, and only 17.5% in 80% of trips.

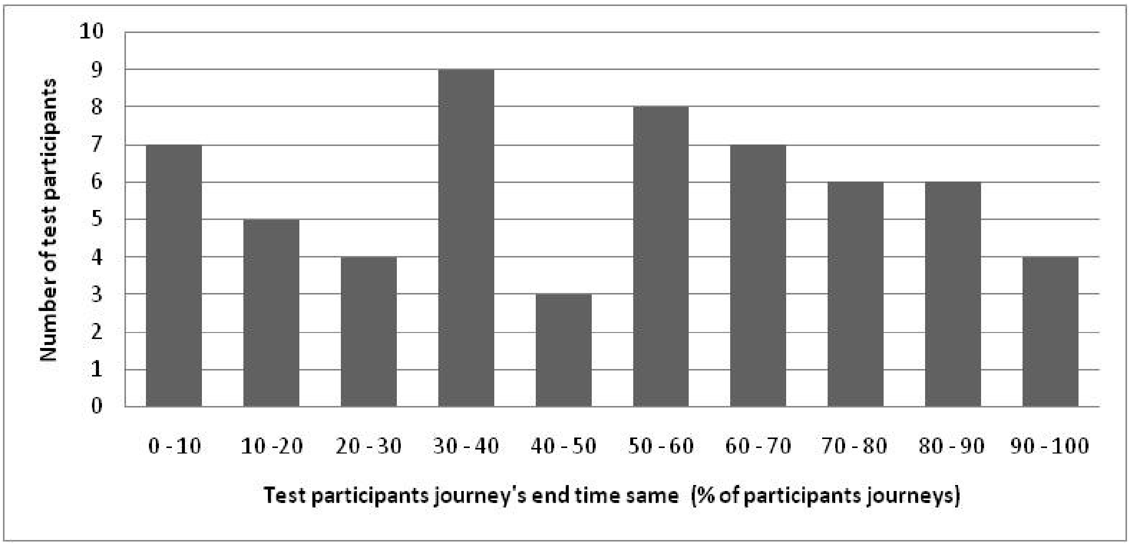

Figure 25. Trip ending time matching in TD and logger data, per person. The accepted error margin was 5 minutes from TD ending time.

Trip ending time matching results were also spread throughout the scale. Here the mode of the results was low at 30-40%, clearly lower than for starting times. This could be because ending time is estimated more often than starting time. The results from starting and ending time matching hint that the starting time is mostly marked down at the beginning of the journey, perhaps at the same time that data logger is turned on, resulting in a fairly puncual starting time. The ending time may be forgotten when arriving at the destination, and is added later based on estimation. The length of the trip is easier to mark down correctly, as it is either known or can be checked, but the time is simply remembered.

TD and logged trips have the same duration in 66.4% of trips. The duration of the trip was considered the same if the logged trip duration was within 10% of the TD trip duration. Within matching durations 65.9% of trips were of exactly the same duration, the TD trip time was longer in 19.2% of trips and the logged trip time in 15.0%. For the 33.6% of trips that did not match, the TD journey duration was usually longer (22.1% of trips for both data sets) than in logger data (11.4%). For TD trip duration longer than logger duration, the difference varied most commonly from 10% to 100% greater (92.9% of non-matching trips), most markedly in the 10-20% difference range (42.1%

of non-matching trips) (Figure 25). As the duration of the trips conflict, it can be deduced that the data collection methods do not log the same times.

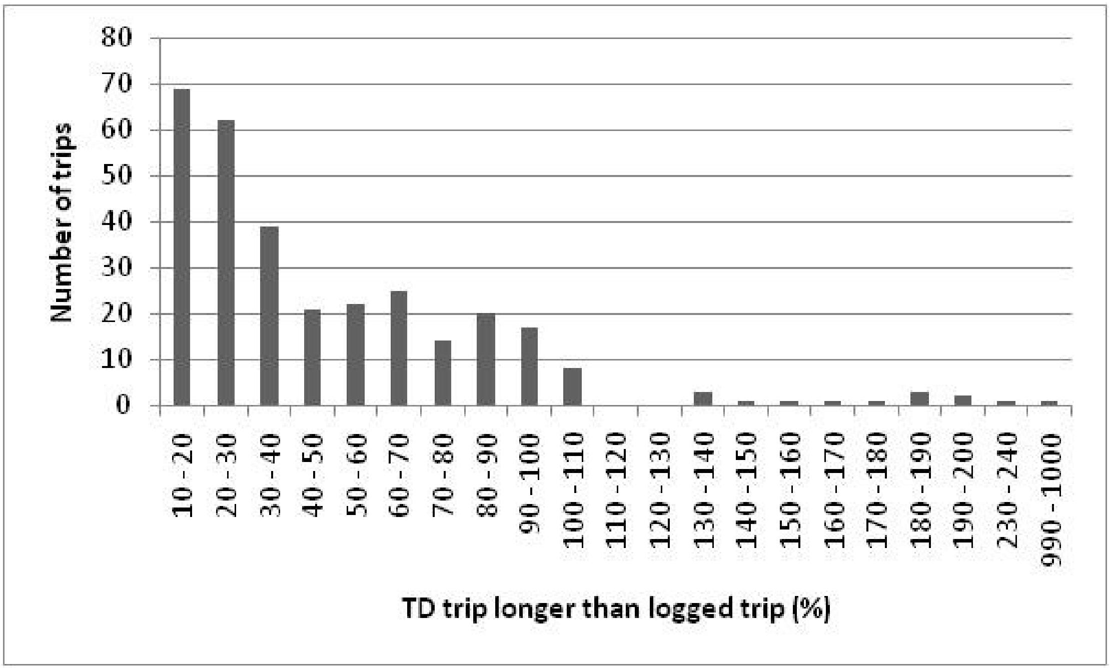

Figure 26. Amount of TD trips having longer duration than logger trips (%).

The primary reason for mismatching could be the inaccuracy in reporting the starting and ending times of short trips in the TD. The duration of the TD trip was defined as the difference between these moments of time. Participants probably marked down an approximation of the starting and ending times, whereas data logger logged actual duration based on its clock. For trips with duration under 20 minutes, a difference as small as 2 minutes causes trip times not to match. Also, if data logger software took some time to start logging, the logged time could end up being shorter than the actual trip.

The proportion of trips with corresponding duration in both data varied per test participant. Only 3.5% of participants had 90-100% of trips with corresponding duration in both data, and 8.8% of participants had 80-100% of trips with corresponding duration (Figure 27). Remarkably, quite a lot of participants (12.7%) had correspondence in duration for only 0-10% of trips. The proportion of trips with correspondence was less than 50% of trips for 63.2% of participants.

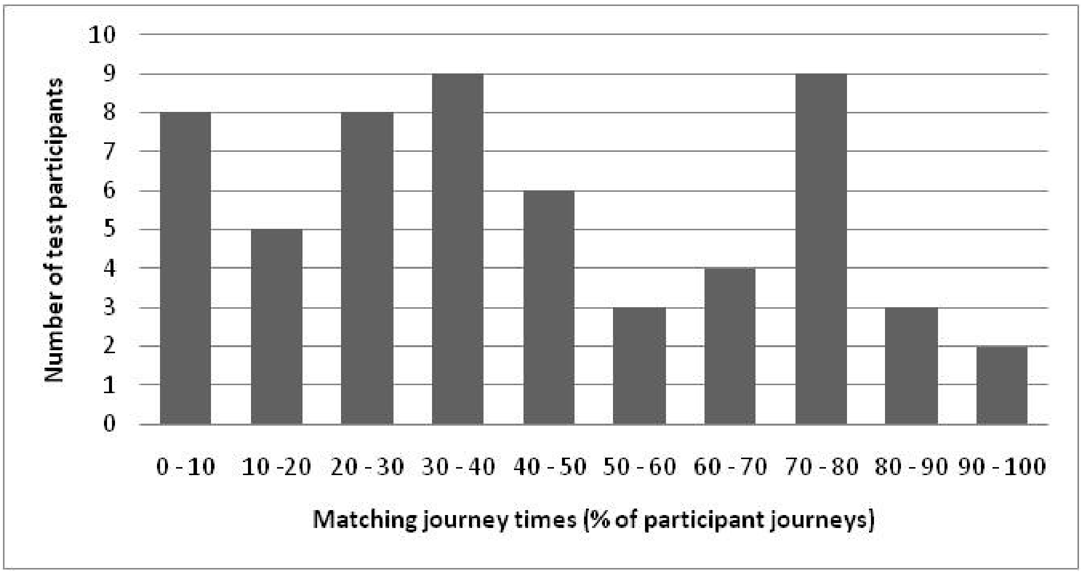

Figure 27. Trips with matching TD and logger data, per person.

4.2.4. Fragmented trips

With the data logger, 83 of TD trips (6.1% of all TD trips made as the driver of a passenger car or van) had fragmented logged trips within the timeframe of a single TD trip. Fragmented logged trips made up 8.9% of the trips having both data sets. Of the 57 test participants having logger data, 59.6% also had fragmented logged trips. However, 44.1% of participants who had fragmented logged trips had only one fragmented logged trip in their data set, and 20.6% had two or three fragmented trips (Figure 28). Consequently, 85.3% of test participants who had fragmented logged trips (50.8% of all participants with logger data) had only up to three fragmented trips. Nevertheless, one participant had up to nine fragmented logged trips.

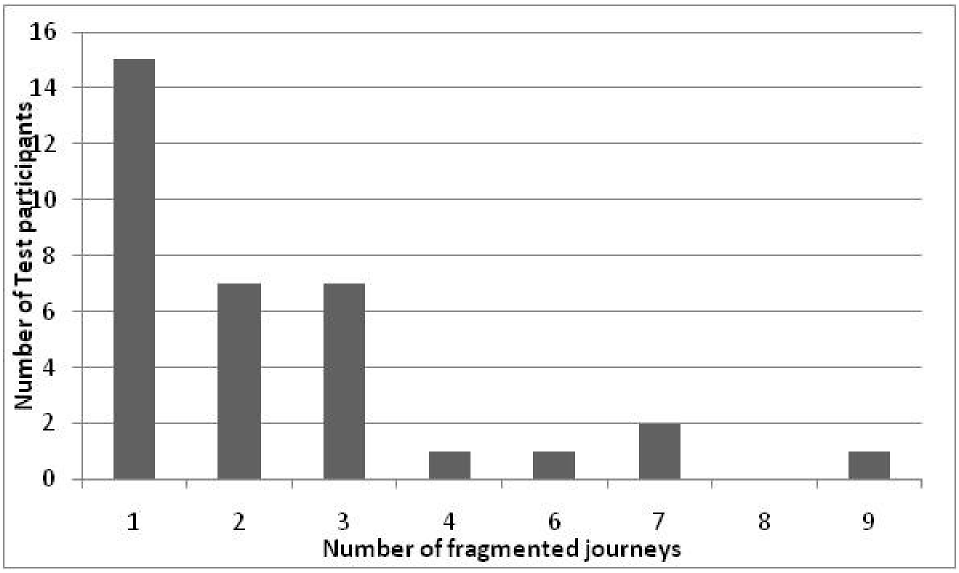

Figure 28. Fragmented logger data trips.

Fragmented trips made up 18.0% of all logged trips. Most of the trips were not fragmented much, as 65.1% of fragmented trips were in two parts and 20.5% in three parts (Figure 29). The number of fragmented trips is alarmingly high and the consequences severe, as it increases the number of test participant-logged trips by creating trips of false length and duration if only the logger data is considered in the analysis.

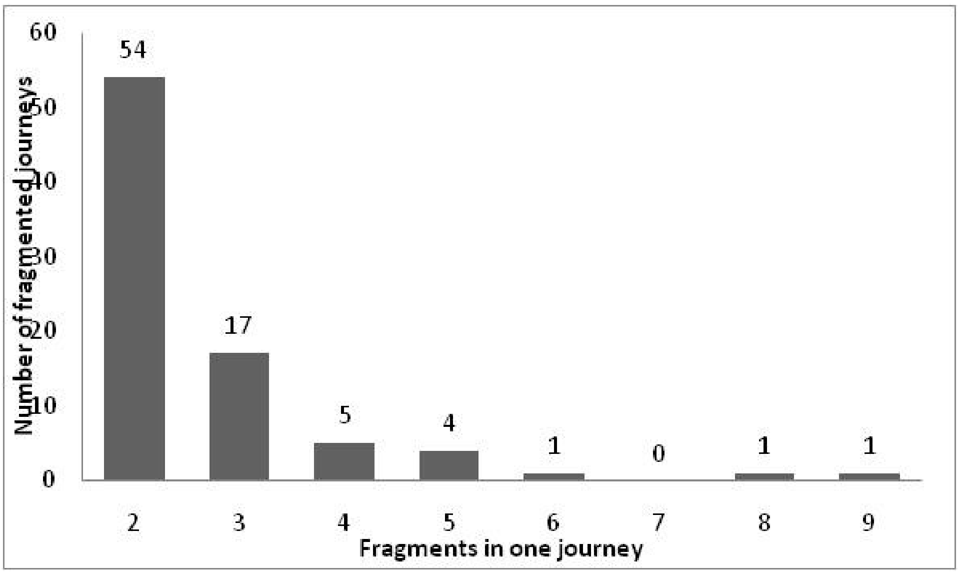

Figure 29. Number of fragments in one trip.

The reasons for the fragmentation can be either human or technical. For longer trips, the test participant may enter the trip in the TD as one single trip from point A to point B, leaving out coffee breaks during the trip that the logger correctly breaks into two separate trips. However, loggers are not totally reliable either: logged trips sometimes missed a comparatively longer part of the trip at the beginning, in the middle or at the end of the trip. Data loggers sometimes ended and started a trip at the same time in the middle of a TD trip. Also in the "Unusual" column of the TD there were complaints about the TeleFOT application not working. All of these factors caused a cluster of logger recordings matching a single TD entry.

There were 11 cases in which more than one TD entry corresponded to the same logger trip. In all of them the destination of the trip had been changed in the TD, so entering it as a new trip in the TD was in accordance with the guidelines given to the participants. If the participant did not remember to change the destination and the gap between trips in the TD was from 0 to 2 minutes, the data logger could not distinguish the change of trip. This is one clear error source that cannot at present be overcome, because the logger should not be able to record a short stop at for example traffic lights as two separate trips.

For fragmented trips the duration was determined as the difference between the first starting time and the last ending time. Logger data fragmentation caused an error in the duration of logged trips, as fragmented trips seem to have lost part of trip from the beginning or end of the trip in addition to some time in between data fragments. Consequently, trip duration matched only in 48.2% of the trips, compared to 66.4% correspondence in all trips having both data. Not surprisingly, TD trip duration was over 10% longer in 41.0% of the fragmented trips.

With trip fragmentation some part of the trip was not logged. However, in 7.9% of fragmented trips the time difference between trip fragments was 0 minutes without change of destination, suggesting user error or data logger malfunction (Figure 30). Driveco should start a new journey automatically only if a car's engine has been turned down for 2 minutes or the user has changed the trip purpose (business or personal). The most common break durations are 1 to 2 minutes, resulting in 34.2% of trip breaks (Figure 30). There are multiple reasons for the error, starting with loss of the Bluetooth connection to the user shutting down the equipment.

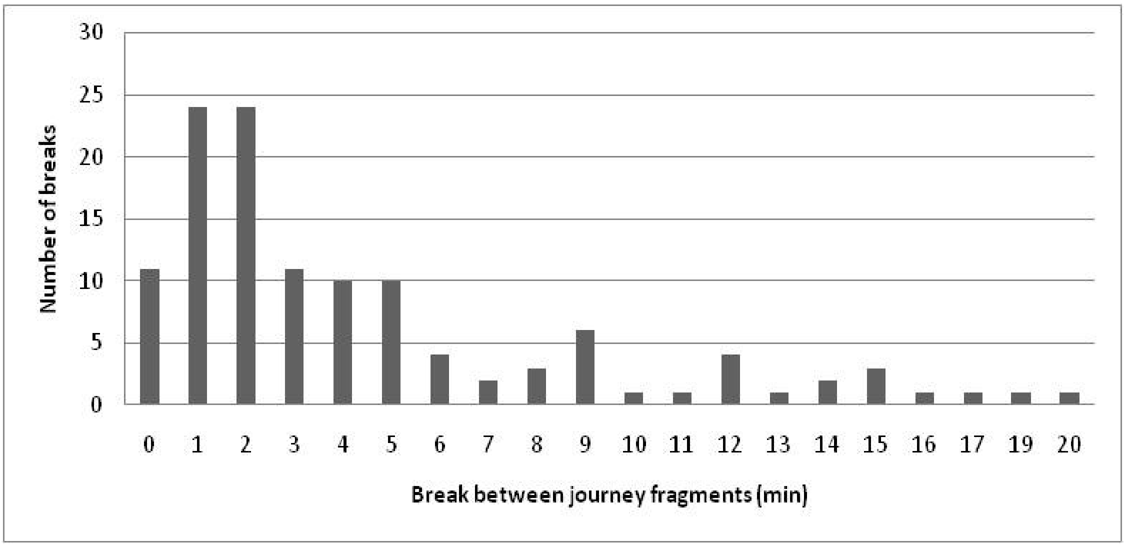

Figure 30. Time between two fragments of a trip.

Breaks that lasted over 20 minutes made up 12.9% of all breaks, having a maximum length of 2 hours 35 minutes (Table 5). Breaks this long between two trip fragments have to be either because of user error or software or device malfunctions.

Table 5. Break between trip fragments that lasted over 20 minutes.

Minutes	Number of Breaks
20 - 30	4
30 - 40	2
40 - 50	2
50 - 60	3
60 - 200	7

Because of logger trip fragmentation, up to 265 minutes of a logged trip were lost (Table 6). The time missed between logged fragments was up to 10 minutes in 66.3% of fragmented trips. Interestingly, in four trips fragmentation had not lost any of the logged trip duration.

Table 6. Missed trip time in fragmented trips.

Minutes	Logged Journeys
0 - 10	55
10 - 20	8
20 - 30	8
30 - 60	5
60 - 300	7

Regarding trip length 50.6% of fragmented trips had a trip length within 10% of the corresponding TD trip length. In 42.2% of fragmented trip data, the TD trip was longer than the fragmented logged trip. In 2.5% of the trips, TD trip length was up to 90-100% longer than the summed length of the fragmented logged trip (Figure 22), suggesting logger use error.

4.2.5. User diligence

Test participants are likely to differ in their diligence in completing the TD and using the data logger. The 54 test participants who had both data were divided into three groups based on the amount of trips having both data per total amount of trips. Groups were classified as Good (80-100% of TD trip had a logged counterpart) with 19 test participants, Mediocre (50-80%) with 22 test participants, and Poor (0-50%) with 13 test participants. These groups' results in terms of correspondence of start and end times, trip duration and trip lengths were studied. The studied factors were also divided into three parts along the same percentages.

With this division two extremes were identified (Table 7). Only in the "Good" group were the participants with matches in the 80-100% category ("good-good" match) more prevalent than others (except in trip duration matching). Having well corresponding data sets does not make them perform as well in other areas, as in the group there were still participants with poor matching of data.

Table 7. Having both data vs. matching of both data. The cell with most participants in each row is shaded. "Good" between 80-100%, "Mediocre" between 50-80% and "Poor" between "0-50%".

	Matching	Good (19 test participants)	Mediocre (22 test participants)	Poor (13 test participants)
Start time	Good	16	0	0
	Mediocre	3	16	0
	Poor	0	6	13
End time	Good	10	0	0
	Mediocre	8	13	0
	Poor	1	9	13
Journey time	Good	5	0	0
	Mediocre	10	6	0
	Poor	4	16	13
Journey length	Good	9	0	0
	Mediocre	8	12	0
	Poor	2	10	13

The “Poor” with the least amount of trips found in both data is a sad example, as all the 13 participants had poor matching in all the studied areas (Table 7). The test participants in this group clearly had trouble with their motivation or data logging, needing extra concentration to perform better. With more motivation, help and training some of them could move to the upper groups.

When studying the “Poor” group more closely in terms of demographics, it is anything but uniform. Only two of the 13 participants are female, the date of birth has a 37-year range from 1943 to 1980, they own seven different brands of car, and they have had a driver’s license for 11 to 50 years.

The group “Good” is not as uniform in the results: in none of the factors studied did all the participants achieve the highest percentile match. Still, the number of participants having a “Good” or “Mediocre” result always beat the number in the “Poor” group. In terms of demographics they are just as mixed as the “Poor” group: three out of 19 participants are female, the date of birth has a 30-year range from 1954 to 1984, and the test participants own 11 different brands of car. The number of participants in this study was so low that no clear definition of “Good” and “Poor” participants could be made. The definition would be interesting to make with a greater data set.

5. DISCUSSION

This study was designed to define the concept of mobility in the context of ITS. Another purpose was to describe the method used in TeleFOT for mobility impact assessment. Especially, the purpose was to validate the reliability of the use of TD data and data logged directly from the vehicle together as an analysis method.

Mobility is concluded to be willingness to move along with potential and realized movement rather than just physical movement of vehicles, people and goods. Along with transport and infrastructure it encompasses people and road users' attitudes, opinions and choices in their daily travelling and movement. The concept of mobility is hard to define accurately, and is often reduced to transport or mixed up with accessibility or efficiency.

There has not been much research on the mobility impacts of ITS as a whole, but there are studies in individual areas. For example, a study of navigator trip planners has shown that having access to pre-trip information can make it easier to reach one's destination, and thus generate trips that would not otherwise be made. As yet there are few ways to study mobility in this context — those found are questionnaires, TDs and the fairly new data loggers. In TeleFOT, all are used to gather data about test participants' mobility and user uptake related to mobility. A TD is kept for a defined time span of 7 days on appointed weeks during the FOT, three to four times depending on the length of the FOTs.

In general the TDs were filled with delightful diligence, as 96.3% of TDs returned by 73% of test participants were fully completed. However, only 66.6% of trips were found in both data sets. There are several possible reasons why data was missing. For missing trips in logger data, participants might have forgotten to turn the application on, the device might have malfunctioned, or the trip was made in another vehicle than the logged car. Therefore 100% correspondence cannot be expected. As for missing TD trips, the reason is mostly test participants having forgotten to mark them down. Tests with human participants are always vulnerable to differences in reliability. The results prove that participants had the skill to use data loggers quite well, but it was forgotten or chosen not to be used by many participants on many trips.

The length of a logged trip had no effect on whether the trip was reported in the TD or not, pointing to the test participant rather than any systemic error of the device. However, 14.9% of trips missing a corresponding TD entry were shorter than 200 m even though participants had been instructed not to include very short vehicular trips. The number of these short trips may also partly explain the over-representation of logged trips with some test participants: The participants had probably had data loggers activated also when moving the car, causing “ghost trips”. These short trips should not be considered as trips outside the TD, but as cases where the trip should be filtered from the logger data. By eliminating these trips from the data the test validity was improved.

Trip starting times corresponded in the data much better than did ending times (91.9% versus 83.0%). There was no difference in diligence in marking the times down. The results hint that the test participants were the cause of the problem. The starting time is most likely entered at the beginning of the journey, possibly at the same time that the data logger is turned on. The ending time, however, might be left out when arriving at the destination, and entered later based on an estimation of the arrival time. The estimation of time is harder to make than for example the length of the trip, which is relatively easy to check afterwards. In trips of duration under 20 minutes, a difference as small as 2 minutes causes trip times not to match, requiring the participant to enter the ending time very quickly if exact results are desired.

Based on the results, driving transportation and personal business trips are more prone to be unlogged in proportion to their total number made. There are still a greater number of commuting and leisure trips left unlogged than transportation and personal business journeys. A higher TD-logger data ratio would be achieved if participants could be got to log commuting and leisure trips more duteously, for example by getting them to feel that they benefit most from the systems in e.g. congested commuting conditions.

The number of fragmented logged trips was alarmingly high (18.0%) in the logged data. Fragmentation creates trips of false length and duration, and impairs the reliability of logger data results. Reasons for data fragmentation can be attributed to both human and technical sources, like combining two separate trips as one (such as omitting a coffee break or losing the Bluetooth connection), but they should be addressed to improve the validity of data logging.

Interestingly, when the test participants having both data were divided into three groups based on their amount of TD-logged trip pairs, differences emerged. The same division corresponded to their results in matching of TD and logger data variables, such as accuracy of the trip timing or trip length, only participants from the best group scoring the best results and every participant from the poorest group having poor results. No specific group demographics were found, but it would be interesting to study whether demographic-specific groups would emerge in a larger number of participants. The results indicate wide personal differences in test participants' diligence and accuracy in answering the TD and using the logger device.

In principle, the data logger offers more precise information about journey duration and length. TD reliability depends on the test participants' willingness to respond and the accuracy of their answers. In addition, since TD concerns self-reported behaviour, there is no guarantee on the correctness and completeness of the responses as the behaviour is reported in the aspect of subjective mobility. The data logger gets the information straight from the car's OBD-II interface, collecting what is assumed to be valid data. However, in practice the reliability of logged start and end times of journeys may be questionable due a possible delay in activation of the logging system or problems with the device. Nor were all the trips logged, as 40.7% of TD trips missed corresponding logged data. Even if some of those journeys had been driven with another vehicle, that leaves some of the trips unaccounted for. Also, 59.6% of participants in this study had fragmentation problems that diminish the reliability of logged journeys.

The data logger device used in this study did not work as reliably as hoped when compared to the TD results. The percentage of trips logged was only 59.3% of all the trips reported as driven in the TD, which does not give enough data to make a comprehensive study with only logger data. The technology may have been found too hard to use, or had problems of its own. At present it is not a very good tool for use alone in a mobility impact assessment study.

The decision as to whether the mobility impact analysis should be based on TD or logger data – in cases where this decision is relevant – would be difficult to make. Both data gathering modes have their uses and strong points. The TD is more reliable in multimodal surveys and is able to compile the reasons for trips being made, thus giving a valid picture of a person's mobility. Data loggers, on the other hand, may be valid and reliable as tireless data collectors in driving style studies. For long duration studies, data loggers offer a way to automate the data collection, offering a chance to collect accurate data for months. Even though TDs were answered with diligence in this study, the accuracy might diminish if the study were to continue for several weeks.

6. CONCLUSION

In conclusion, mobility is a broad concept dealing with the movement, feelings and attitudes of people. It has to be studied from several different angles, and the answer to the question “mobility” can be composed from several fragments of information. TDs and data loggers currently have their own usages for which they are excellent — TDs in multimodal surveys and data loggers in detailed car studies. Activated data loggers do not yet work perfectly in collecting data about people’s everyday mobility, but with technical development it could create a good method for motorized vehicle data collections.

The main implications of this study are the image of accuracy and endurance of Nordic test participants in using a TD and a logger device that has to be specifically activated. Based on the results, the average participant tends to be quite scrupulous and meticulous when dealing with a TD, but this attitude deviated with the use of data loggers. The results of TD-logger data correspondence divided participants into three groups: “good”, “mediocre” and “poor” based on their performance in matching data on the trip start time, trip end time, trip duration and length.

This study only gives a picture of Nordic participants. It would be very interesting to see how the results of simultaneous use of an activated data logger and TD and the rate of TD entry would differ in central or southern Europe. Another interesting follow-up would be to see whether a larger test sample of participants would fall into clear demographic groups based on performance.

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APPENDIX 1 – MOBILITY RESEARCH QUESTIONS IN TELEFOT

RQ1	Is the number of journeys undertaken affected in total?
RQ2	Is the number of other home related journeys affected?
RQ3	Is the number of other journeys affected?
RQ4	Is the length of journeys in distance affected?
RQ5	Is the duration of journeys affected?
RQ6	Is there a change in commuting mode of travel?
RQ7	Is there a change in route choice in commuting?
RQ8	Is there a change in departure time of a commuting journey?
RQ9	Is there a change in travelling in adverse conditions (dark, fog, slippery road, etc.)?
RQ10	Is there a change in user stress?
RQ11	Is there a change in user uncertainty?
RQ12	Is there a change in feeling of subjective safety?
RQ13	Is there a change in feeling of comfort?

(Gaitanidou et al. 2010)

APPENDIX 2 – TRAVEL DIARY

Country:	City / FOT:	Person:	Date (DD/MM/YY) : / / 201

Fill in one row for each trip that you make during the day. You may use either words or the codes given on the back cover.

Where did you start your trip from? (Examples on back cover) ORIGIN	What was your destination? (Examples on back cover) DESTI-NATION	At what time did you start the trip? (hh:mm, 24 h clock) START TIME	What time did you end the trip? (hh:mm, 24 h clock) END TIME	How long was the trip? (100 m accuracy) TRIP LENGTH	List the modes of travel, in the order (sequence) in which you used them. (Examples on back cover) MODES OF TRAVEL	What was the primary mode of travel? (Used for the longest distance) PRIMARY MODE	What was the purpose of the trip? (Examples on back cover) PURPOSE	Which TeleFOT functions did you use before leaving the origin? (List on back cover) BEFORE	Which TeleFOT functions did you use during trip? (List on back cover) DURING	Which TeleFOT functions did you use after arriving to the destination? (List on back cover) AFTER	Write down anything unusual about this trip, e.g adverse weather, accident or event causing congestion, etc. UNUSUAL?
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							
		:	:	.... km .... m							

TeleFOT

Figure 31. TeleFOT travel diary first page.

Origins and destinations

1	Permanent residence (own home)	8	Supermarket, shopping centre or other retail location
2	Other residence (including holiday/weekend residence)	9	Location related to personal business (bank, office, doctor, etc.)
3	Own place of work	10	Restaurant, cafe or similar
4	Own school or place of study	11	Place of leisure activities
5	Business trip related location	12	Hotel or similar
6	Place to pick up person or goods	13	Other location, describe
7	Day care, children's school		

Travel modes

1	Walking, running, kick sled, kick bike, walker, wheelchair, skis, rollerblades etc.	9	Train
		10	Taxi, inva-taxi
		11	Aeroplane, helicopter
2	Bicycle	12	Motorcycle
3	Passenger car or van, as passenger	13	Moped, moped car
4	Passenger car or van, as driver	14	Skidoo, all-terrain vehicle
5	Local bus (including service lines), school transport	15	Water transport (boat, ship, ferry)
		16	Truck/lorry
6	Long distance coach	17	Tractor/self propelled, (road maintenance vehicles etc.)
7	Metro		
8	Tram	18	Other form of transport, describe

Trip purposes

1	Commute to work, commute home (or to other residence)	5	Personal business (to/from)
		6	Lunch/eating/restaurant visit (to/from)
2	Business trip (usually a work related trip paid for by one's employer, to/from)	7	Transporting another person or goods (to/from)
3	Trip to/from school, place of study	8	Leisure activities (to/from)
		9	Vacation travel (to/from)
4	Purchase of daily goods, shopping trip (to/from)	10	Other trip, describe

TeleFOT functions

GD	Green Driving	TI	Traffic Information
SA	Speed Alert	NS	Navigation (static)
SI	Speed Information	ND	Navigation (dynamic)

TeleFOT

Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles

TeleFOT Travel Diary

Write down all trips made during the survey days in the diary.

INSTRUCTIONS

A trip is moving from one place to another for an end purpose. A trip can comprise one or more modes of transport. **Remember that most trips include a walking part.** A trip that includes only walking should also be logged. However, short walking distances (e.g. less than 5 minutes) at origin or destination should not be included. If you are uncertain whether you should report your travelling as one or two trips, report it as two.

The purpose of a trip home is the original main purpose for leaving home.

Example:

		Origin	Destination	Purpose
TRIP 1	From home to children's day care	1	7	7
TRIP 2	From children's day care to work	7	3	1
TRIP 3	To a meeting outside the office	3	5	2
TRIP 4	Back from the meeting	5	3	2
TRIP 5	From work to a eye doctor	3	9	5
TRIP 6	Home from the eye doctor	9	1	1
TRIP 7	From home to a petrol station	1	8	8
TRIP 8	From petrol station to a swimming pool	8	11	8
TRIP 9	Home from the swimming pool	11	1	8

You may complete the diary using the codes shown on the back cover or verbally.

THOSE TRAVELLING ON A PREDEFINED ROUTE (like bus drivers) should only log trips that are not related to these predefined route selections. The trip to and from work should be logged.

THE SURVEY DAY starts at 4am and ends at 3:59am the following day. Your personal survey dates are stated in the covering letter. This means that you should log the trips you make during those days (separate diary table for each day).

TRIPS are logged in the chronological order (sequence) in which they were made during the day.

TeleFOT functions:

- Green driving provides support to the driver in order to reduce the environmental impact of driving where possible.
- Speed alert displays the current speed of the vehicle and the current speed limit of the road/street. A warning is issued when the speed limit is exceeded.
- Speed information displays the current speed of the vehicle and the current speed limit of the road/street used. No warning included.
- Traffic information is a system that provides drivers with real-time information about the status of the traffic system independent of navigation.
- Navigation guides the user to a destination set beforehand. Dynamic navigation takes into account the actual (and real time) status of the traffic system or other pre-selected topics, static navigation does not.

Picture 1. TeleFot travel diary second page.